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Agricultural Research in Africa
A Review of USAID Strategies and Experience

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Foreword

In 1992, the U.S. Agency for International Development, Africa Bureau, Office of Sustainable Development, Productive Sector Growth and Environment Division (USAID/AFR/SD/PSGE)* began a process to redefine the strategies and approaches it was promoting in agricultural research in Africa. Central to that process was a reexamination of the strategies, experiences, and lessons of past efforts. This report on *Agricultural Research In Africa: A Review of USAID Strategies and Experience* made a significant contribution to our understanding of the strengths and weaknesses of past efforts.

This review of past strategies complements several other studies that explore the prospects for alternative approaches to agricultural research in Africa. These studies include an examination of the role of the private sector in agricultural research in Africa, case studies on public private sector collaboration, and a review of the subsector approach to technology development and transfer (TDT). The efforts also include participation in and support for the design of Frameworks for Action, a regional coalition development coordinated by the Secretariat of the Special Program for African Agricultural Research (SPAAR), as well as dialogue with many professionals and policymakers within and outside of Africa.

The process to redefine the Africa Bureau's approach has led to the development of a *Strategic Framework for Agricultural Technology Development and Transfer in sub-Saharan Africa*. The Strategic Framework provides guidance to USAID Missions in Africa, African institutions, and the Africa Bureau in the design of strategies and identification of priorities for agricultural TDT. It builds on past experiences and lessons articulated in this report.

This review was completed by Dr. Cheryl Christensen of the U.S. Department of Agriculture, Economic Research Service. Her insight and analysis has greatly contributed to our understanding of what strategies work and don't work in Africa. Among the key lessons emerging from this review is that both African research systems and development assistance are evolving to reflect the economic reality that technology and research are necessary, but not sufficient in themselves for sustainable economic development. Research is not an end in itself, and, to be effective, it must be linked to other key support services—both public and private—including input and output market development, policy, and resource management.

I especially thank Dr. Christensen for both completing this review and participating in a broad discussion of the report, which included USAID officers, U.S. university scientists, African scientists and policymakers, and other members of the international research community. Thanks also goes to USAID personnel who supervised this activity, including Richard Newberg and Michael Fuchs-Carsch.

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Executive Summary

In a time of shrinking resources, the U.S. Agency for International Development (USAID), other donors, and African governments recognize the need for clear investment priorities. It is therefore prudent to examine past investments in agricultural research in Africa. *Agricultural Research in Africa: A Review of USAID Strategies and Experience* summarizes USAID's explicit or implicit agricultural investment "strategies" and the lessons learned from successive approaches. It also contrasts several cases where agricultural research was widely adopted and made a significant impact on national or regional production patterns with other cases where research was not successful. It identifies the major elements of successful and unsuccessful cases of technological adoption. Finally, it translates these lessons and patterns into recommendations for refocusing agricutural investment in Africa.

Part I. Research Strategies and Investments

USAID's Strategies for Agricultural Research

Prior to the development of the Plan for Supporting Agricultural Research and Faculties of Agriculture in Africa (subsequently referred to as the Plan) in 1985, USAID did not have a formally articulated strategy for agricultural research in Africa. USAID did, however, have assumptions about agricultural research and development which shaped its priorities and focus, and constituted de facto "strategies" for agricultural research. These implicit strategies tended to be global rather than regional. However, developments in Africa tended to reflect these broader trends faithfully.

<u>(1) The Pre-USAID Period: Low Emphasis on Agricultural Research, 1950s–1960</u>

Throughout the 1950s and early 1960s, U.S. assistance programs paid relatively little attention to agricultural research. They focused primarily on extension and building agricultural universities. This focus reflected the pervasive assumption that the technology needed to improve agricultural productivity already existed in developing countries and that the major focus should therefore be on creating institutions that could quickly and effectively disseminate this technology.

<u>(2) The Early Foreign Assistance Act Experience, 1961–65</u>

The Foreign Assistance Act, passed in 1961, established USAID and much of its institutional structure (e.g., regional bureaus, functional accounts). USAID inherited the previously dominant research paradigm, focused on spreading existing technologies through education and extension. The assumption that available technology was relevant to developing countries was only beginning to be questioned. While overall assistance to Africa increased dramatically as countries rapidly achieved independence, agricultural research received relatively little support, not only because of the emphasis on existing technology, but also because USAID personnel believed that funding agricultural research would violate the "spirit" of its restriction on supporting food grain production that conflicted with U.S. (agricultural) interests.

(3). The Green Revolution Impact, 1966–1973

By the mid-1960s, the impact of the Green Revolution technologies and the beginning of a global agricultural research network changed the research landscape. While USAID did not participate in the creation of the International Agricultural Research Centers (IARCs), it did begin to fund these centers after 1968, when a six-year ban on USAID support to research on "surplus crops" ended. "Green Revolution" research increased interest in transferring and adopting the new technologies to other tropical zones and supported more emphasis on "adaptive" research.

(4) The New Directions Thrust 1973–1980

The New Directions legislation, passed in 1973, required USAID to focus its programs on the "poor majority" in developing countries. This mandate, combined with a deeper understanding of constraints to technology adoption, led to a focus on designing technology to address the needs of small farmers, including those in resource poor areas. There was also a heavier focus on staple food crops produced by small farmers, such as millet, sorghum, and cassava. The sense of urgency associated with the "World Food Crisis" of the early 1970s also increased attention toward agricultural research, especially research oriented toward increasing food production.

Title XII of the 1975 Foreign Assistance Act encouraged support for the IARCs and provided a mandate to engage U.S. universities more directly in international food research. USAID got two new mechanisms to support agricultural research: the Collaborative Research Support Program (CRSP) and strengthening of grants to U.S. universities. Title XII also established the Board for International Food and Agricultural Development (BIFAD) to mobilize university resources as well as to work with and advise USAID. Regional research arrangements, such as the Semi-Arid Food Grain Research and Development Project (SAFGRAD) were also introduced. The primary research thrust during this period was on food crop production, with a secondary emphasis on livestock.

(5) Commitment to Agricultural Research, 1981–1991

By the 1980s, USAID was committed to making systematic and sustained investments in agricultural research, both through its own projects and through contributions to the operation of the international centers. The philosophy that underlay this commitment, as well as the principles that provided the foundations for USAID's strategy, were embodied in the Plan.

The Plan recognized that improved technology was necessary to achieve agricultural progress in Africa, as well as acknowledged that the difficult physical environment, labor constraints, and a generally weak research base on African food crops would make research difficult. It recognized the need for adaptive research and national agricultural research systems capable of performing it. The Plan established a 20- to 25-year planning horizon for investments in Africa's agricultural research capacity.

The Plan also established country and commodity criteria for prioritizing USAID's agricultural investment. USAID would make its greatest investments in *technology-producing countries*, supporting both technology generation and adaption/utilization and would strengthen *technology-adapting countries'* capacities to screen, borrow and adapt technology from other sources. The Plan firmly committed USAID to *commodity research* and established criteria for commodity and research topic selection. The highest priority commodities were maize, millet, sorghum, upland rice, roots and tubers (cassava and potatoes), and edible legumes (beans and cowpeas). USAID specifically excluded research on locally important crops without importance in Africa's overall food needs (e.g., groundnut, soybeans, horticultural crops). The Plan also supported international and regional commodity networks. USAID's priority commodity networks were Maize, Sorghum and Millet, Roots and Tubers, Edible Legumes, Upland Rice, and Forages in Mixed Farming Systems. Finally, the Plan called for annual expenditures of $50 to $75 million annually for national programs, $10 to $15 million for commodity networks, and $20 million per year to support IARCs, CRSPs, and other centrally funded projects in Africa.

USAID's Investment in African Agricultural Research

USAID's allocation of *real* resources to sub-Saharan Africa have varied substantially over time, in part in response to the general swings in development strategy and priorities noted above. The general data show a high level of resources (in constant dollars) provided in 1963, with subsequent sharp declines. Total U.S. assistance to Africa still falls short of the amount provided during that period in constant dollars, while USAID's assistance only recently reached those earlier levels. The sharp drop in assistance to Africa during the late 1960s and early 1970s probably reflects the closing of country missions and consolidation of African activity triggered by the Korry Report.

Data on USAID's expenditures for agricultural research, education, and extension similarly show a significant drop from $17.1 million in 1965 to 5.9 million in 1970. Most investment during this period, however, went to agricultural extension and education. Agricultural research received very little support during this period. Only Nigeria had any investment in agricultural research before the early 1970s. In the remaining countries, a few small investments were made in the early 1970s. USAID's investment in African agricultural research increased significantly in the late 1970s, however. USAID's total agricultural research budget for Africa reached $15.9 million in 1978, $32.6 million in 1979, $28.6 in 1980, and $41.7 in 1981. These figures significantly underestimates U.S. investment in African agricultural research, since much of the research investment comes from regional accounts, which have fared relatively well in constant dollar terms.

Over the past five years, USAID's bilateral investments in African agricultural research have declined, from about $35 million in 1986 to about $28 million in 1990. Regional obligations fell even more sharply, from about $10 million in 1986 to $3 million in 1990. In constant dollars, expenditures for African agricultural research in 1990 were below their 1980 levels.

Part II. Lessons Learned from Successive Approaches

A principal lesson learned by the late 1970s technologies developed often did overcome the constraints faced by small farmers. The failure to reduce these constraints was the major reason for low rates of technology adoption.

USAID and other donors also found that it was often more difficult to directly address these constraints than had been initially envisioned. These constraints included resource limitations (poor soils, inadequate water, peak labor shortages, and lack of capital), as well as the need to assure subsistence food supplied and to reduce the risk of crop failure. Farming systems research played an important role in *documenting* these constraints, but less so in producing viable alternatives for transcending them.

By the mid-1980s, with the experience of attempting to implement a much more ambitious program of assistance to African agricultural research, some additional lessons were clear.

First, virtually all USAID research projects underestimated (or rediscovered) the importance of institutional constraints and national-level policies to the conduct and dissemination of agricultural research. While many projects reported institutional "lessons learned," these lessons were in some sense misinterpreted. They were generally seen as issues of *project implementation* rather than as signals for the need to look more fundamentally at the design and operation of research institutions themselves.

Second, there was a growing recognition of the importance of sectoral and national policies in constraining research. In some instances, research efforts were concentrated on crops characterized by heavy government intervention, including the establishment of unfavorable producer prices and inefficient input supply systems. These factors significantly affected farmers' ability to adopt new technologies as well as their economic incentives to do so.

Third, USAID and other doners recognized the high cost of of food self-sufficiency policies and the resulting focus on increasing production of food crops to the exclusion of other commodities. Food self-reliance was a more effective approach to food security. This recognition, however, did not translate into a full blown appreciation of the importance of building realistic economic assessments into research priorities.

Fourth, the experience with networks (while mixed) suggested that the networks could provide effective vehicles for making a much wider range of germplasm directly available to local scientists but their proliferation reduced their cost-effectiveness.

Fifth, there was a growing appreciation for the importance of noncommodity research, especially in areas which impacted the agriculture system as a whole and threatened the sustainability of agricultural activities. Research on soils, integrated pest management, and agroforestry was undertaken, although these efforts were small compared to commodity production research.

Finally, USAID, as well as other donors, came to realize that too little attention had been paid to documenting and analyzing the impact of research. Many evaluations noted that impacts could not be measured because accurate baseline data were lacking.

Part III. Patterns in Successes and Failures

While agricultural research has not brought a Green Revolution in Africa, there have been enough cases of broad research adoption to suggest some features associated with successful and failed adoptions. The complete report, *Agricultural Research in Africa,* analyzes successfully disseminated research techologies in maize, cotton, potatoes, beans and cassava and compares features of these successes with reviews of failed research activities. The comparison reveals clear patterns associated with successful research adoption:

1) In virtually all successful cases, there has been both an improvement in physical technology that increased production and productivity and a supportive market for the commodity.

2) Sucessful cases of research adoption in the absence of a cash market are relatively rare and are associated with severe threats to household food security (e.g., cassava).

3) Research designed to increase production of subsistence crops has rarely been successful, especially when higher yields require purchased inputs or major modifications of established (mixed cropping) systems. Technologies have often been uneconomical or at variance with farmers' objective functions.

4) In the most successful cases, there have been effective links between commodity markets, input supplies (e.g., fertilizer, seed, agrochemicals, equipment), and credit. Partial success has been possible where markets existed, but input supplies were imperfect. Poorly functioning markets and unreliable input systems have led uniformly to failure.

5) There are several viable approaches for creating a supportive market system, including vertically integrated systems (involving either public or private sector organizations), informal markets, and liberalized, relatively competitive markets.

6) Many technologies have not been successfully adopted because they have not addressed key constraints. Often these have been constraints that were not commodity specific (e.g., labor availability, rainfall variability).

7) Technologies that successfully loosened key constraints (such as animal traction in West Africa) have sometimes created growth opportunities in multiple parts of the agricultural sector.

Part IV. Conclusions and Recommendations

The previous review of strategies and adoption suggests two over-arching conclusions.

Conclusion 1: Marketing Systems Are Crucial

The primary conclusion is that the operation of markets plays a critical role in the adaption of technology. This is true at the micro level, where the issue is economic feasibility for a particular farmer. It is also true at the sectoral level. The most successful cases of technological adoption occur when there are viable internal or external markets. More effective adoption occurs when there are effective links to inputs (via vertical integration or well functioning input markets) and marketing (again through vertical integration or efficient marketing systems). Market considerations should also shape research priorities. Research on commodities for which there is no viable internal or external market is unlikely to lead to widespread adoption or generate a substantial economic impact.

The challenge of an agricultural research strategy relevant to the 1990s is to develop a *workable* link between the dynamism and opportunities created by policy reform and privatization and the technological improvements that can flow only from agricultural research, and that are essential to sustaining the growth policy reform makes possible.

USAID, as well as other donors involved in policy-based lending, are at a crucial turning point. Policy reform, a necessary condition for making investment in both enterprises and technologies worthwhile, must now depend on such investments to deliver the increases in growth and welfare that African nations need so desperately. At this juncture, therefore, it is of critical importance that sound investments in improved productivity be made and that they be made in areas where they can provide the greatest possible support for the ongoing policy reform process.

Conclusion 2: Research Systems Need To Be Results Oriented

An important institutional conclusion is that institutions—even research institutions—need to be results oriented. Results need to be defined not only in terms of the number of research products produced (papers, trials, etc.) but in terms of the wider, practical utility of the products. It also appears, however, that the best way to achieve this orientation is for research institutions to have direct, and real, links to the agricultural marketplace in their countries. This does not imply that there must be immediate payoffs to all agricultural research, but rather that there must be some significant portion of the research system which is *profoundly* geared toward responding quickly and effectively to market realities.

These two conclusions, plus the lessons learned from previous strategies and the success and failures of adoption, support several recommendations for future research strategies:

1) Identify and capitalize upon research that will directly support *enhanced growth*.

2) Focus on key aspects of the nonfarm components of agriculture which offer opportunities for significant reductions in cost and/or opportunities to break key constraints to growth.

3) Make a major commitment to drawing into both national and international research systems private sector organizations, especially in areas where privatization is key to ongoing reform efforts.

4) Focus explicitly on noncommodity research that can address major African production and marketing problems.

5) Broaden the commodity coverage of research to include research on the production and marketing of crops that have significant potential as export crops and/or commercial development within the country.

6) Make decisions on country and institutional priorities not only on the basis of their capability to produce research results but also on the capacity to translate research into tangible impacts.

7) Build the identification and assessment of impacts into both the organization and the conduct of research programs and research institutions.

Glossary of Acronyms and Abbreviations

ADP	Agricultural Development Project
AFR	Bureau for Africa
ARTS/FARA	Office of Analysis, Research, and Technical Support / Division of Food, Agriculture, and Resources Analysis (USAID/AFR; now SD/PSGE)
BIFAD	Board for International Food and Agricultural Development
CFDT	Compagnie Francaise pour le Developpement des Fibres Textiles
CGIAR	Consultative Group on International Agricultural Research
CID	Consortium for International Development
CILSS	Comité Inter-Etats de Lutte contre la Sécheresse au Sahel (Interstate Committee for the Fight against Drought in the Sahel)
CIMMYT	International Maize and Wheat Support Center
CIP	International Potato Center
CORAF	Conférence des Responsables de Recherche s Agronomiques Africaines et Française
CRSP	Collaborative Research Support Program
DFA	Development Fund for Africa
FAO	Food and Agriculture Organization of the United Nations
FSR	farming systems research
GDP	gross domestic product
IARC	International Agricultural Research Center
ICRISAT	International Center for Research in the Semi-Arid Tropics
IGGAD	Intergovernmental Authority on Drought and Development
IITA	International Institute of Tropical Agriculture
INSAH	Sahel Institute
INYSOY	International Soybean Program
IRA&T	Institute for Africultural Research and Training
IRAZ	Institut Recherche Agronomique Zaire
IRRI	International Rice Research Institute
KARI	Kenyan Agricultural Research Institute
MADIA	Managing Agricultural Development in Africa

NARS	national agricultural research systems
NGO	nongovernmental organization
OAU	Organization of African Unity
PNAP	Rwandan Potato Research Program
SAARFA	Strengthening African Agricultural Research and Faculties of Agriculture Project
SACCAR	Southern African Centre for Cooperation in Agricultural Research
SADC	Southern African Development Coordinating Committee
SAFGRAD	Semi-Arid Food Grain Research and Development Project
SCO	SAFGRAD Coordination Office
SD/PSGE	Office of Sustainable Development / Productive Sector Growth and Environment Division (USAID/AFR, formerly ARTS/FARA)
SODECOTON	Cameroon Cotton Development Company
SPAAR	Special Program for African Agricultural Research
USAID	U.S. Agency for International Development

Introduction

In a time of shrinking resources, the U.S. Agency for International Development (USAID), other donors, and African governments themselves recognize the need for clear investment priorities. It is therefore prudent to examine the case for or against continued investment in agricultural research in Africa, as well as to examine the consistency of those investments with others being made by USAID. It is particularly important to look for means of tailoring these investments to achieve the most immediate impacts possible on the performance of the agricultural sector.

Agricultural Research and Growth in Africa

The conjunction of a general worsening of agricultural conditions and increased investment in agriculture and agricultural research has led to questions about the utility of further investment in agricultural research in sub-Saharan Africa. The gains associated with agricultural research in Asia during the development of the Green Revolution have proved elusive in sub-Saharan Africa. Yet this should come as no surprise to those familiar with the African setting. A decade ago, there was broadly based consensus that while African agriculture could not match the growing demand for food without technologically based increases in productivity, the "models" for technological change developed in the United States and Asia could not be effectively transferred to most of sub-Saharan Africa. New research, responsive to the variety and complexity of sub-Saharan Africa's agricultural environment, would be needed to support more intensive, higher productivity production. It was also clear that pursuing these objectives had a 20- to 25-year time frame.

During the 1980s, many of the dismal forecasts for sub-Saharan Africa's agricultural performance were confirmed. So was the assessment that research offered little that could be pulled off the shelf for a short-term "quick fix." The crises created, however, did catalyze a willingness to address some of the deep-seated policy constraints to agricultural production, and the importance of the performance of the agricultural sector to overall economic growth.

As countries undertook policy reforms, both local governments and international donors gained greater experience with the constraints and lags involved in implementing policy reform. Recent World Bank reviews of the experience with policy adjustment lending concluded that in sub-Saharan Africa the lags experienced in the agricultural sector's response to policy changes were a major factor in the region's lack of economic growth. The lags were often attributable to nonprice factors, such as weak infrastructure and a lack of the productivity-increasing technologies needed to support an aggregate price response.

This experience, and earlier analysis, suggests a strong need to maintain and refocus investment in agricultural research. Without improved productivity, sustainable increases in economic growth will not be achieved. However, increases in productivity are needed not only in agricultural production, but also in agricultural marketing and processing. Indeed, research in some of these areas can both support policy reform initiatives and facilitate the adoption of improved technologies by African farmers. Donor support for research will play a critical role in the future of African agriculture.

Economic pressures focus government attention on immediate crises and concerns. These pressures have both weakened national financial support for agricultural research and created inefficiencies in the use of national research resources. Even so, the capabilities now in place are significantly better than they were a decade ago. Economic crises provide opportunities for constructive change, including more efficient organization of national research structures (for example, the recent reform of the Kenyan Agricultural Research Institute [KARI]); the establishment of clearer, more achievable research objectives; and opportunities to involve the private sector more significantly in agricultural research.

Within this difficult environment, research investments are beginning to show positive results, although not on the scale that characterized research in Asia. First, in some instances, research results played a rather direct role in increasing commodity production and preventing an even more significant deterioration in agricultural production. The most dramatic example is the development of improved maize varieties, which have been widely disseminated. Second, research has led to increased production of key export crops, with corresponding increases in farm income and agricultural sector development. The most dramatic example of this is cotton production in francophone Africa. Third, research efforts appear to be producing a body of both physical and socioeconomic information that is contributing both to an unlearning of erroneous "conventional wisdom" and to knowledge of the broader physical and socioeconomic environment that is critical to relevant research. Finally, investments in training researchers have now begun to produce a larger cadre of qualified researchers. Many of these researchers work under harsh and unpromising conditions. However, network activities and research support have helped stimulate commitments to higher quality professional work.

These positive observations, of course, should not be taken as signs that research is about to produce a Green Revolution in sub-Saharan Africa, that researchers with inadequate equipment and support will by the sheer force of motivation produce breakthroughs, or that changes in the focus and direction of research are unnecessary. They do indicate, however, that in many instances progress has been made, and that the United States and African countries have much to lose if these capabilities are not marshalled to directly support policy reforms with technological advances.

Why the Research Focus Needs to Be Broadened

Technological progress, reflected in increased productivity, is a critical component of the ability of the agricultural sector to contribute to economic growth. The classic paradigm is that significant increases in productivity associated with agricultural technology or innovation create an expanded food supply, which in turn lowers per unit food costs. Lower prices stimulate demand, making it possible for farm income to rise by selling a greater quantity of food at a lower unit cost of production and a lower unit price. Income growth over time stimulates demand for a wider range of agricultural products, including animal protein, higher valued vegetables and fruits, and more processed foods (Engel's law).

The type of innovation that will produce these productivity gains depends on both the physical environment and the socioeconomic environment. The physical environment in much of sub-Saharan Africa creates production constraints that are quite different from those prevailing in Western countries or Asia. This complicates the "transfer" of agricultural technologies from other regions and requires a heavier investment in site-specific research. This has been one of the major lessons learned by a decade of physical science research in Africa.

The economic environment in Africa is also considerably different from that which prevailed in other countries that experienced significant agricultural revolutions. The same was true of the Asian economic environment vis a vis the Western countries, like the United States, which were the source of the initial agricultural revolutions. Hence, the Green Revolution technologies had different features—as the literature demonstrates. Economists have found that relative prices (as summaries of demand relationships and factor endowments) have a major impact on the development and spread of technological innovation (induced innovation).

For induced innovation to occur, relative price relationships must somehow be linked to the process of research and technology development. How strong these links are depends on the nature of the economic environment itself (for example, how market oriented it is) and the ties between markets and research establishments. Links are strongest in a commercial market environment. but sometimes at the cost of a shorter term perspective and a lack of attention to public goods. Links are intermediate in public research settings where there accurate information on economic realities is available.

For a combination of institutional, policy, and historical reasons, economic "realities" (as experienced by the majority of farmers) have not been accurately fed into the postindependence research apparatus of the national agricultural research systems (NARS). In the colonial period, with a heavier emphasis on cash-crop production for the world market, relevant economic information was more accessible because colonial administrations and institutions focused heavily on profitability and tightly controlled local "cash-crop" economic environments in ways oriented toward the world market. During the postindependence period, many African governments adopted policies and institutions that distorted, or destroyed, the operation of markets. The prevalence of such policies and institutions were frequently a serious constraint to agricultural research.

We are beginning to see changes that could make market-oriented innovation more relevant to sub-Saharan Africa and, hence, make technological change more relevant to economic growth. Farming systems research and associated social science perspectives with a more "empirical" approach to African farmers, such as on-farm research, have (albeit imperfectly) generated more accurate information on economic as well as sociocultural realities. This information has often been unavailable from more "official" sources, such as macroeconomic data or official price series, for a variety of reasons, including:

- a significant divergence between "official" and "unofficial" markets (and less accurate knowledge of the latter);
- ignorance of economic (and other) realities of production on units that do not benefit significantly from subsidies (for example, credit, inputs) and/or are producing commodities not controlled by the government (subsistence food crops, "minor" crops); and
- policy distortions, which should decrease as policy dialogue increases.

As policies and institutions change, the United States should be prepared to refocus its research to support these changes. More explicit research on commodity marketing and input supply systems is needed to complement micro level studies of farm practices. Change in the marketing/institutional structure of the "agribusiness" sector is likely to be more rapid than changes in the physical environment. Macroeconomic policy changes may alter some key features of reality at the farm level—including changes in input availability, wage rates, and marketing channels that could impact technology adoption. The research agenda must be defined to make it as likely as possible that new technologies are available to support transformation across the entire agricultural system.

1. USAID's Agricultural Research Strategies and Their Evolution

USAID's Strategies for Agricultural Research

Prior to the development in 1985 of the "Plan for SupportingT USAID did not have a formally articulated strategy for agricultural research in Africa. USAID did, however, have assumptions about agricultural research and development that shaped its priorities and focus, and constituted de facto "strategies" for agricultural research. These implicit strategies tended to be global rather than regional. However, developments in Africa tended to faithfully reflect these broader trends.

The Pre-USAID Period: Low Emphasis on Agricultural Research (1950s-1960)

Throughout the 1950s and early 1960s, U.S. assistance programs paid relatively little attention to agricultural research.[1] They focused primarily on extension and building agricultural universities. This focus reflected the pervasive assumption that the technology needed to improve agricultural productivity already existed in developing countries and that the major focus should therefore be on creating institutions that could quickly and effectively disseminate this technology.

The Early Foreign Assistance Act Experience (1961-65)

The Foreign Assistance Act, passed in 1961, established USAID and much of its institutional structure (for example, regional bureaus, functional accounts).

The dominant development paradigm continued to emphasize spreading existing technologies. The transfer and extension of U.S. agricultural technology continued to be regarded as the best way to ensure that the rural sector could contribute to development. The assumption that available technology was relevant to developing countries was only beginning to be questioned.[2]

Agricultural research received little support, not only because of the optimistic assumptions regarding the appropriateness of existing technology but also because USAID personnel believed that funding agricultural research would violate the "spirit" of its restriction on supporting food grain production that conflicted with U.S. (agricultural) interests.[3] The emphasis on creating extension programs and institutions of higher learning continued. (See discussion below)

During this period, USAID significantly increased the number of its bilateral missions, including the establishment of missions in most of the newly independent countries of sub-Saharan Africa. To focus its activities across such a broad range of countries, USAID instituted a system of country classification. Countries in the first category had most of the prerequisites for development other than adequate external assistance (for example, they had a relatively advanced public administration system, long-term prospects for political stability, and, by implication, an adequate planning capability). These countries would receiveT in this category.[4] Countries in the second category lacked some of the pre-requisites for development. In these cases, prolonged assistance was seen as premature, and assistance focused on the identified priorities of the country itself. The third category was composed of countries unlikely to reach a point of becoming self-sustaining for some time to come. Aid to such countries would need to be flexible, experience-based, and unlikely to create an obligation for increased assistance by USAID or other donors.

USAID's early extension efforts focused on trying to build national extension systems based on the U.S. model and on improving methods for disseminating information to farmers. Investments made in pursuit of these objectives, however, tended to be less successful than envisioned. There were several lessons to be learned from this experience, including:

- technologies developed in temperate zonesffrequently performed poorly in tropical environments; and
- farmers did not adopt the technologies offered because they faced constraints (both physical and socioeconomic) that made the technology inappropriate to their situation.

USAID also invested heavily in creating and supporting agricultural universities in developing countries. Between 1951 and 1966, USAID and its predecessor organizations invested nearly $150 million in contracts with U.S. universities for providing technical assistance to develop agricultural colleges.[5] The U.S. land grant system—with its tripartite mission of teaching, research, and extension—was the institutional model for these efforts.The focus of this investment was primarily on teaching and curriculum development. Heavy teaching loads and lack of research funds meant that research depended primarily on the initiative of individual faculty members and did not develop as an institutional commitment.

There was at least one "institutional" lesson to be learned from the early investments in agricultural universities. Developing country universities, unlike U.S. land grant universities—did not and were not likely to—play a major role in agricultural research. Universities needed considerable development to support the teaching mission, an area in which some universities are still weak. While this capacity was being developed, research capabilities were created in other institutions. Agricultural research was conducted primarily in government programs in the ministry of agriculture, national research centers, or production-oriented organizations.[6]

The Green Revolution Impact (1966-73)

By the mid-1960s, the impact of the Green Revolution technologies were beginning to be felt in Asia. This impact led to the beginning of what is now a global agricultural research network.T Maize and Wheat Support Center (CIMMYT) and the International Rice Research Institute (IRRI) began a process of creating international agricultural research institutes, organized under the CGIAR (Consultative Group on International Agricultural Research) in 1972. While USAID did not participate in the creation of the International Agricultural Research Centers (IARCs), it did gradually provide support to these centers. Beginning in 1969, with assistance to CIMMYT, USAID began to fund some of the international centers engaged in "green revolution research." This was made possible in 1968 when a six-year ban on USAID support to research on "surplus crops" was ended.[7] This led to considerable interest in transferring and adopting the new technologies to other tropical zones. It also supported a greater emphasis on "adaptive" research, and ultimately focused more attention on policies and institutional arrangements that blocked the adoption of improved technologies and the need for improved training in policy formulation and analysis.[8]

At the same time (circa 1967), USAID underwent internal changes that had a significant impact on its African programs. The Korry report advocated a shift toward a multilateral and regional framework, with multilateral organizations taking the lead in Africa and USAID filling in with specific activities. In keeping with this reduced role, USAID phased out 22 of its 33 African missions as projects were completed. USAID made no new bilateral development loans or technical cooperations starts in these countries.[9] Finally, the substantive focus shifted to education and training, food, population, health, private sector, and physical infrastructure.

USAID also changed its funding modalities, introducing program loans, conditional on policy performance. By FY 1967, about one-third of USAID's agricultural assistance came through program loans, used to finance the export of U.S. fertilizer, and engineering skills to build plant capacity in developing countries themselves.[10] USAID also supported greater private sector and nongovernmental organization (NGO) involvement in agriculture.

The New Directions Thrust (1973-80)

The New Directions legislation, passed in 1973, required USAID to focus its programs on the "poor majority" in developing countries. This mandate, combined with previous lessons on the importance of constraints in technology adoption, led to changes in USAID's agricultural research objectives, which persisted from 1974 to 1982. These were summarized by a USAID evaluation report as follows:[11]

- an increasing attempt to design technology that addresses a broad range of small farmer constraints, both physical and socioeconomic; and
- an increasing attempt to design technologies for resource poor areas (for example, the Sahel) and a heavier focus on the crops produced by small farmers, including staple food crops such as millet, sorghum, and cassava.

The shift in objectives, in turn, implied changes in agricultural research methodology. USAID's evaluation report summarized these as follows:[12]

- a greater focus on adaptive research, conducted on small farms;
- increased emphasis on communication among researchers, extension agents, and farmers;
- more interdisciplinary agricultural research, including the involvement of economists, anthropologists, and nutritionists (embodied in the concept of farming systems research [FSR]);
- increasing emphasis on the role and importance of strong national research networks in developing countries that are capable of adapting technologies received from the IARCs; and
- greater realization within the development community that more time is needed to implement agricultural research projects than had previously been projected.

During this period, there was also an increase in the number of bilateral missions in Africa, at least in part in response to the severe famine in the Sahel during the early 1970s. The sense of urgency associated with the "World Food Crisis" of the early 1970s also increased attention toward agricultural research, especially research oriented toward increasing food production.

This increased attention was translated into both increased research funding and the creation of new mechanisms to support agricultural research. During the 1974 World Food Conference, Secretary of State Henry Kissinger pledged that the United States would triple its contribution for the international research centers, for agricultural research in developing countries, and for research by American universities on agricultural problems in developing countries.[13]

In 1975, Title XII of the Foreign Assistance Act ("Famine Prevention and Freedom from Hunger") provided additional support for agricultural research.[14] Title XII created authorities to provide program support to the IARCs, to involve universities more fully in international agricultural science networks, and to support long-term collaborative university research on food production, distribution, storage, marketing, and consumption. It also established the Board for International Food and Agricultural Development (BIFAD) to mobilize university resources, advise USAID, and participate in agricultural development policy formulation, project design, and U.S. universities' work with USAID.

Two new categories of USAID support for agricultural research emerged from the Title XII legislation. The first was the Collaborative Research Support Program (CRSP). CRSPs provideT least 25 percent of the total project cost. The second funding mechanism was strengthening grants to U.S. universities. These grants were designed to help universities locate and develop staff with the capacity to work on long-term overseas assignments.

This was also a period of experimentation with regional research arrangements. The Semi-Arid Food Grain Research and Development Project (SAFGRAD) was initiated in 1977 as a \$13.3 million dollar project which combined an Organization of African Unity (OAU) coordinating role with USAID funding for both international centers—the International Institute of Tropical Agriculture (IITA), International Center for Research in the Semi-Arid Tropics (ICRISAT)and a U.S. university (Purdue) for research on millet, sorghum, maize, and cowpeas.[15]

The primary research thrust during this period was on food crop production, both within USAID and across the donor community. The DEVRES survey of agricultural research projects in the Sahel, for example, determined that in 1983 over half of the 289 agricultural research programs/projects in that region were focused on crops research. Livestock research accounted for another 26 percent.[16]

In some instances, this translated into programs that supported the achievement of "self-sufficiency" in food crops, almost irrespective of considerations of economic efficiency or comparative advantage.[17] This led to some serious economic difficulties. Government policies sometimes included the stimulation of production in basic food crops through high guaranteed prices. Demand for these crops during years of good production was limited, leading to costly surpluses. Research to support increased production of such commodities was, in retrospect, misguided.

Commitment to Agricultural Research (1981-91)

By the 1980s, USAID was committed to making systematic and sustained investments in agricultural research, both through its own projects and through contributions to the operation of the international centers. The philosophy that underlay this commitment, as well as the principles which provided the foundations for USAID's strategy, were embodied in the Plan for Supporting Agricultural Research and Faculties of Agriculture in Africa (subsequently referred to as the Plan).[18]

The Plan recognized that improved technology was necessary to achieve agricultural progress in Africa, as well as acknowledged that the difficult physical environment, labor constraints, and a generally weak research base on African food crops would make research difficult. The Plan also affirmed the importance of building national agricultural research systems. Because agricultural technologies are often location specific, and very sensitive to the agroecological environment, as well as the socioeconomic characteristics of farmers, national research systems would have to be able to identify, screen, and interpret technological alternatives and even to effectively borrow research results. A time frame of 20 to 25 years was seen as the planning horizon for investments in Africa's agricultural research capacity.

The Plan established country and commodity criteria forprioritizing USAID's agricultural investment.

Country Criteria

USAID would make its greatest investments intechnology-producing countries, supporting both technologygeneration and adaption/utilization. These countries were definedby the following criteria:

- at least 100,000 hectares of land planted in each commodity for which research assistance was planned;
- a research staff of 100 or more scientists (with a minimum of 8 to 12 scientists assumed necessary to make significant progress on any one commodity);
- three or more functioning research stations in key agricultural areas of the country;
- a national research system pursuing prioritized commodity and problem-solving research;
- a national research system with working relationships with IARCs, CRSPs, neighboring national programs, and regional programs;
- a national budget that demonstrated steady support and reasonable per scientist funding; and
- a faculty of agriculture with the capacity to teach and do research, providing B.S. level students qualified to pursue graduate studies at African universities.[19]

USAID would provide assistance to strengthen the capacities to screen, borrow, and adapt technology from other sources in technology adapting countries. These countries were defined by the following criteria:

- cultivated area for priority crops of about 100,000 hectares;
- an agricultural research staff of 20 to 80 scientists;
- two or more operating research stations;
- a national research system willing to establish research priorities;
- a national research system interested in and willing to establish regularized working relationships with IARCs and other research institutions outside the country;
- national leadership that indicated a willingness to consider funding recurrent and operational costs of national research institutes and to provide reasonable per-scientist research support; and
- a faculty of agriculture with some capacity to provide B.S. graduates to serve on commodity research teams and qualify for graduate training.[20]

Commodity Priorities

The Plan firmly committed USAID to commodity research and established criteria for commodity and research topic selection. These criteria included:

- the extent to which the commodity contributed to present and projected calorie intake in rural and urban areas;
- the likelihood that improved farmer-relevant technology could be developed to increase production, given the expertise and state of the art in the United States and IARCs;
- the availability within the national research system of a minimum cadre of 4 M.Sc. or Ph.D. scientists backstopped by a staff of 8 B.S. level specialists to work on priority research problems; and
- a U.S. comparative advantage in providing knowledgeable scientists and relevant technology that could be incorporated into an ongoing research program.

The United States was believed to have a comparative advantage in food crops, rather than export crops. The highest priority commodities were: maize, millet, sorghum, upland rice, roots and tubers (cassava and potatoes), and edible legumes (beans and cowpeas). USAID specifically excluded research on locally important crops without importance in Africa's overall food needs (for example, groundnut, soybeans, and horticultural crops).[21]

The Plan also included a major commitment to commodity networks, both as a means of overcoming some of the difficulties of small, thinly staffed research institutions and as a means for fostering better information exchange, coordination, and cooperation. USAID's priority commodity networks were Maize, Sorghum and Millet, Roots and Tubers, Edible Legumes, Upland Rice, and Forages in Mixed Farming Systems.

Finally, the Plan established significant levels of target spending for agricultural research in Africa over a 15-year period. It planned to commit \$50 to \$75 million annually for national programs, \$10 to \$15 million per year to support commodity networks, and some \$20 million per year to support IARCs, CRSPs, and other centrally funded projects in Africa.[22]

Lessons Learned from Successive Approaches

A principal lesson learned by the late 1970s was that the technology promoted in the past often did not overcome or alleviate many of the constraints faced by small farmers. The failure to alleviate these constraints was the major reason for low rates of technology adoption.[23]

USAID and other donors also found that it was often more difficult to directly address these constraints than initially envisioned. The constraints included resource limitations (poor soils, inadequate water, peak labor shortages, and lack of capital), as well as the need to assure subsistence food supplied and reduce the risk of crop failure.[24] FSR played an important role in documenting these constraints, but less so in producing viable alternatives for transcending them.

Third, conducting on-farm trials—a step toward orienting research more directly to actual farm conditions—was more difficult and costly than initially anticipated, both for the World Bank and for USAID. The specific research problems involved in conducting such research included both a difficulty in directly focusing research on actual small farmer constraints (for example, labor constraints, mixed cropping systems) and problems in conducting research on small farms created by high transportation costs, unavailability of vehicles, and the need to design controls.[25] Despite the difficulties involved, however, on-farm trials have proved helpful in transferring technology and new seed varieties to farmers and gaining farmer feedback.

By the mid-1980s, with the experience of attempting to implement a much more ambitious program of assistance to African agricultural research, some additional lessons were clear.

First, virtually all USAID research projects underestimated (or rediscovered) the importance of institutional constraints and national level policies to the conduct and dissemination of agricultural research. While many projects reported institutional "lessons learned," these lessons were in some sense misinterpreted. They were generally seen as issues of project implementation rather than as signals for the need to look more fundamentally at the design and operation of research institutions themselves. World Bank projects encountered problems similar to those identified by USAID in its project appraisal reports (for example, poor research management, failure to recruit staff, budget cuts and inadequate support, lack of procedures for research planning and priority setting, weak inter-institutional coordination and linkages to extension). The Bank concluded, however, that these difficulties were generally overcome in "free-standing" research projects, most of which were successful in achieving a significant portion of their objectives.[26]

Second, there was a growing recognition of the importance of sectoral and national policies in constraining research. In some instances, research efforts were concentrated on crops characterized by heavy government intervention, including the establishment of unfavorable producer prices and inefficient input supply systems. These factors significantly affected farmers' ability to adopt new technologies as well as their economic incentives to do so.

Third, there was an emerging awareness of the importance of commercial markets for research adoption. Some of the so-called "minor" crops covered by USAID-funded research (for example, roots and tubers, beans) apparently saw more effective adoption of research results in part because these crops were important in the informal economy. Researchers could obtain fairly accurate economic signals with even relatively small surveys. Farmers appeared to have built such economic information into their production practices and used it to cope with resource and factor constraints. The availability of local/regional markets for these crops made the spread of significant innovation possible.

By the 1980s as well, the tacit focus on food self-sufficiency had given way to the more realistic concept of food self-reliance. Research activities, such as those conducted by Michigan State University team, were instrumental in shifting governments away from rigid food self-sufficiency policies in a number of countries (for example, Mali, other Sahelian countries, Zimbabwe).[27] This recognition, however, did not translate into a full-blown appreciation of the importance of building realistic economic assessments into research priorities.

Fourth, the experience with networks (while mixed) suggested that the networks could provide effective vehicles for making a much wider range of germplasm directly available to local scientists—for example, beans and cassava in East Africa; the Strengthening African Agricultural Research and Faculties of Agricullture (SAARFA) network. This pattern makes it more likely than it was a decade ago that research results can be effectively linked to agricultural productivity. However, the proliferation of networks appears to have reduced the cost-effectiveness of these activities.

Fifth, there was a growing appreciation for the importance of noncommodity research, especially in areas that impacted the agriculture system as a whole (for example, soil fertility and management in humid West Africa) and that threatened the sustainability of agricultural activities (for example, environmental degradation). Increased research on soils, integrated pest management, and agroforestry reflected this awareness, although the level of research effort devoted to these topics remained small in comparison to resources devoted to commodity production research.

Finally, USAID, as well as other donors, came to realize that too little attention had been paid to documenting and analyzing the impact of research. Many evaluations noted that impacts could not be measured because accurate baseline data were lacking.

Omissions of Past USAID Strategies

Despite an increased focus on FSR, designed to delineate the constraints facing farmers and to make agricultural researchersT production oriented. Relatively little emphasis was placed on examining other crucial parts of the agribusiness sector (including policies, input supply and marketing, performance of markets for commodities produced, agricultural policies).

In addition, relatively little economic analysis of the profitability of research was conducted. This is particularly apparent as an extensive review of recent production research has found that technologies are unprofitable, given labor requirements and undistorted input prices.[28] The significance of input subsidies in maintaining even the relatively low use of fertilizer is becoming clear, as levels of fertilizer use have dropped significantly in countries where exchange rate devaluation and/or subsidy removal have exposed farmers to new market realities.

As a result of the former omission, relatively little attention was focused on research in transportation, marketing, handling, or institutional changes that could either reduce the costs of input delivery (as opposed to subsidizing them) or examining the role markets and the possibilities for income enhancement that might flow from them.

The Michigan State work, among others, also demonstrates that conventional wisdom has underestimated the involvement of rural households with the market, particularly with domestic markets for foodstuffs. Poor performance of these markets (for example, their thin nature, lack of financing for private sector traders) apparently has hindered the willingness of at least some farmers to move toward producing foodgrains for the domestic market.

The Relevancy of the Plan

The Plan constituted a step forward in that it attempted to develop criteria for focusing resources into higher potential research environments. It has several features that are weaknesses in the current environment.

- The plan discusses only what is necessary to achieve technical agricultural research breakthroughs, and consciously separates this from what is necessary to achieve production breakthroughs (for example, infrastructure, input supply systems, marketing, and substantial policy reform).

- The document retains a relatively narrow focus on the production aspects of agriculture. It omits the importance of research on other aspects of the agricultural system (for example, inputs, markets, processing) as well as the importance of research in other disciplines related to these areas (for example, policy, economics, etc.)

- The commodity priority system downplays the importance of noncommodity research (for example, soil fertility and naturalT increasingly recognized as key areas for research.

- The commodity priorities selected also have the effect of directing research toward commodities where there is little or no prospect for catalyzing private sector involvement. This is a particularly serious weakness as the development of new private sector orientations in many countries needs to include private sector involvement in research activities.

- Finally, the commodity focus closes off prospects for work in areas that may well be important to a more growth-oriented research strategy (for example, export crops, nontraditional exports, etc.).

- The categorization of countries into technology producing and technology adapting is artificial, and ignores criteria relevant to creating a research impact (for example, the marketing system, policies, and prices), as well as the ability of research in small systems to achieve excellence is specialized areas (for example, Rwandan research in potatoes and beans).

2. Resources Supporting Agricultural Research in Africa

USAID's Investments in African Agricultural Research

USAID's allocation of real resources to sub-Saharan Africa have varied substantially over time, in part in response to the general swings in development strategy and priorities noted above. The general data, presented for the period 1963-84 in Figure 1, show a high level of resources (in constant dollars) provided in 1963, with subsequent sharp declines. Total U.S. assistance to Africa still falls short of the amount provided during that period in constant dollars, while USAID's assistance only recently reached those earlier levels. The sharp drop in assistance to Africa during the late 1960s and early 1970s probably reflects the closing of country missions and consolidation of African activity triggered by the Korry Report.

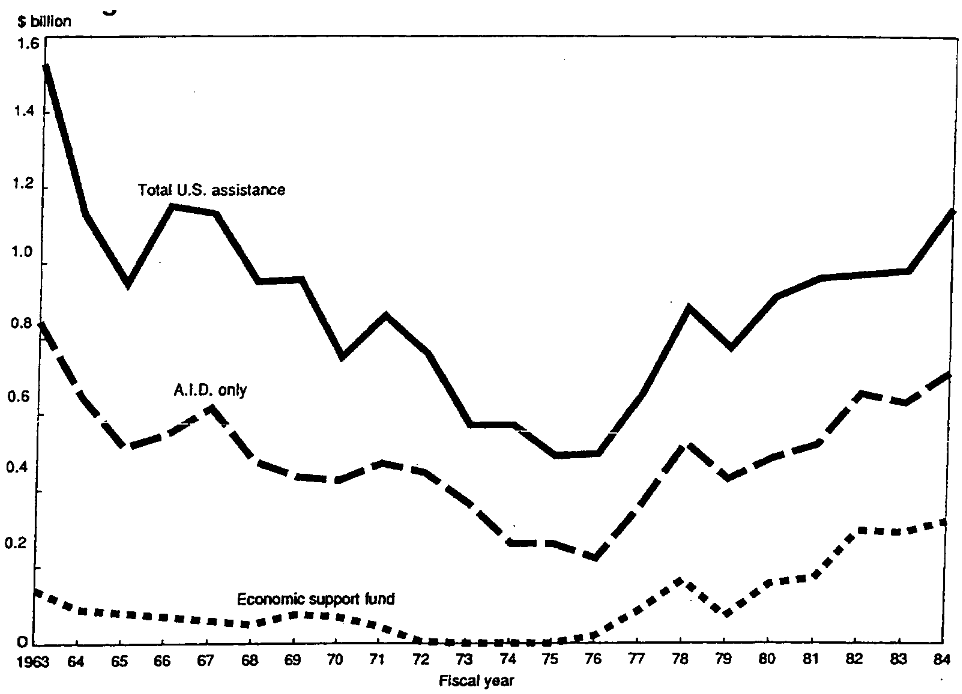
Data on USAID's expenditures for agricultural research, education and extension similarly show a significant drop from $17.1 million in 1965 to 5.9 million in 1970 (see Table 1). Most investment during this period, however, went to agricultural extension and education. Agricultural research received very little support. Bruce Johnson's analysis of the six Managing Agricultural Development in Africa (MADIA) countries (Nigeria, Senegal, Cameroon, Kenya, Malawi, and Zimbabwe) indicated that only Nigeria had any investment in agricultural research before the early 1970s (Tables 2-7). In the remaining countries, a few small investments were made in the early 1970s. USAID's investment in African agricultural research increased significantly in the late 1970s, however. USAID's total agricultural research budget for Africa reached $15.9 million in 1978, $32.6 million in 1979, $28.6 million in 1980, and $41.7 million in 1981 (Table 8). These figures significantly underestimate U.S. investment in African agricultural research, however, since much of the research investment comes from regional accounts, which have fared relatively well in constant dollar terms.

Since the mid-1980s, USAID's bilateral investments in African agricultural research have declined, from about $35 million in 1986 to about $28 million in 1990. Regional obligations have fallen even more sharply, from about $10 million in 1986 to $3 million in 1990 (Figure 2). In constant dollars, expenditures for African agricultural research in 1990 were below their 1980 levels (Figure 3). Since 1990, funding from bilateral Missions has continued to decline.

Other Donor Investments in African Agricultural Research

The investments of other major donors, such as the World Bank, also increased substantially at the time USAID was increasing its expenditures. Bank levels, however, did not decline in parallel with declines by USAID. By the early 1980s, the Bank's overall level of spending for agricultural research had stabilized at about $1.4 billion.29 World Bank investments in agricultural research in Africa continued to increase. The cost of research financed by the Bank in sub-Saharan Africa was $26.4 million in 1981, $79.5 million in 1982, $31.3 million in 1983, $71.4 million in 1984, $76.6 million in 1985, $38.9 million in 1986, and $87.6 million in 1987.30

Figure 1. U.S. Economic Assistance to Africa, 1963-1984



Source: Bruce Johnson et. al. An assessment of A.I.D. Activities to Promote Agricultural and Rural Development in Sub-Saharan Africa (AID, April 1989), p. 19.

Africa's National Agricultural Research Systems (NARS)

The 1960s and 1970s for many African countries were years of transition. Most achieved independence during this period, in some cases followed by instability. Research was sometimes disrupted by the collapse of regional research institutions, the departure of expatriate research workers, and a shortage of trained local researchers. During the 1959-80 period, government expenditures for agricultural research increased fourfold in Africa, compared with a sixfold increase in Asia and Latin America. Spending in 1980 was approximately $380 million.

The picture, however, was dominated by growth in Nigeria, Kenya, South Africa, and Zimbabwe. Growth in these countries offset declines in a number of other countries.[31]

The staffs in African research institutions have also grown significantly, although many assessments still conclude that there is a shortage of well-trained researchers.[32] In 1980, Africa had approximately 5,000 researchers in its public research institutions (Figure 4). Again, however, the national picture varies considerably, from Kenya, with a large agricultural research system, to Guinea Bissau, with a very small system (Table 11). T their agricultural research institutions. On one hand, a certain "critical mass" is necessary to support effective agricultural research.[33]

Many of Africa's research institutes are still rather small (Figure 5). On the other hand, even modest research institutions may translate into a much higher ratio of researchers to agricultural land than exists in larger, more developed countries (see Table 11).

The structure of African NARS varies significantly, with major differences in organization and focus between anglophone and francaphone Africa (see tables 12 and 13). Research institutes are at times affiliated with Ministries of Science (which has often weakened links to farmers), at other times with Ministries of Agriculture or universities.

While significant process has been made in establishing and funding NARS, there are several "gaps" in the existing system that should be recognized.[34] Despite the significant increase in research staff, there is still limited scientific manpower in many of the NARS. Some 29 percent of the agricultural research scientists in the NARS are still expatriates. Only about 40 percent of the nationals in the research systems have M.S. or Ph.D. degrees (Table 10). As a result, the capacity for conducting research is frequently limited.

The need to develop cadres of well-trained agricultural researchers has been made more difficult by both the economic crises facing many African countries and the policies for managing existing NARS. National funding in most instances cannot continue to grow at anything like the pre-1985 rates, and in some cases is declining. Funding constraints, coupled with policies that maintain—or even increase—employment in the NARS, have led to a serious imbalance between personnel and operating costs, resulting in organizations in which the staff lacks the funding to undertake productive research work.

Many NARS also show the consequences of a period of relatively rapid growth. A proliferation of research stations, and relatively unfocused research agendas, demonstrate the need to streamline and focus research systems.

USAID Support to International Agricultural Research Centers (IARCs) and U.S. Universities

USAID's contributions to the IARCs have increased significantly since the mid-1970s. USAID's contributions to individual IARCs prior to the establishment of CGIAR in 1972 were small. Resource commitments increased significantly from $3 million in 1972 to $35 million in 1984 (Figure 6). The Agency's contributions stabilized at this level, then declined slightly in 1987 and 1988. The overall resource base of the CGIAR has continued to grow, and the U.S. share of total CGIAR contributions has declined to less than 20 percent. T U.S. funding for U.S. universities also increased significantly between the late 1970s and the mid 1980s. USAID made extensive use of the new mechanisms established in Title XII, including CRSPs and strengthening grants. CRSPs were developed for a range of basic commodities, including beans/cowpeas, grain sorghum/pearl millet, small ruminants, soils management, human nutrition, peanuts, aquaculture, and integrated pest management.[35] Strengthening grants were provided to support capacity development in a number of broad thematic areas, including a ruminant livestock consortium, a university consortium on tropical soils, an international soybean program (INYSOY), a Consortium for International Development (CID), and an aquaculture and marine resources and agricultural economics consortium.[36] In 1981, USAID's funding for strengthening grants totaled $5.5 million and generated $6.0 million in university contributions.[37]

Table 1. USAID Capital and Technical Assistance Projects in Agricultural Research, Education, and Extension, 1962–72
(millions of dollars)

	FY 1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Agriculture Research, Education, and Extension by Bureau / Region											
Near East & South Asia	3.0	3.1	2.0	10.8	3.1	2.3	3.8	4.1	4.3	4.6	2.5
Latin America	4.6	7.7	8.7	8.2	4.7	8.0	17.8	4.6	5.7	6.5	9.2
Far East	3.0	2.6	2.2	1.7	0.7	0.8	0.8	1.0	1.1	1.6	0.9
Africa	15.1	14.1	.13.4	17.1	14.2	11.2	7.2	6.0	5.9	6.3	15.4
Total Agricultural Research, Education, and Extension	25.7	27.4	26.2	37.7	22.8	22.2	29.7	15.7	17.0	19.0	28.0
Total Food and Agriculture Commitment	134.4	138.1	119.5	100.6	116.6	115.8	83.9	48.3	117.2	112.8	92.3
Total USAID Commitment	960.1	1064.6	1014.5	765.9	691.9	809.9	613.4	480.0	603.3	624.7	580.1
Total Agricultural Research, Education, and Extension, as Percentage of Food and Agriculture Commitment	19.1	19.8	21.9	37.5	19.6	19.2	35.4	32.5	14.5	16.8	30.3
Total Food and Agriculture, as Percentage of Total USAID Commitment	14.0	13.0	11.8	13.1	16.9	14.3	13.7	10.1	19.4	18.1	15.9

Source: Compiled from data available in USAID Statistics and Reports Division Publications Projects By country and Field of Activity, volumes for FYs 1962–72. This publication was not printed after 1971. Figures do not include support assistance, including that to Vietnam. Totats may not add up due to rounding. No explanation is given in the above publications for the wide fluctuation in figures. Funds represent amounts obligated.

Table 2. Sectoral Breakdown of U.S. Assistance to Cameroon, by Year, 1963–84
(in thousands of constant 1983 dollars)

Sector/Subsector	Total	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ASD Project and Program Assistance	207,108	32,709	4,802	16,949	4,252	3,032	30,761	285	5,767	266	255	225	1,647	520	1,491	4,840	17,640	9,909	7,111	8,112	15,529	19,000	22,007
Agriculture	82,719	221	1,376	1,478	377	643	340	94	0	0	0	0	0	0	828	1,937	2,083	6,614	6,315	8,112	15,532	18,768	18,000
Crop production	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage & processing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Input supply	13,497	0	640	942	0	0	0	0	0	0	0	0	0	0	770	420	514	24	157	135	2,095	5,585	2,215
Credit	1,645	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	341	0	506	798	0
Research	5,011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	839	696	670	426	1,060	1,320
Extension	4,987	0	301	138	91	194	170	47	0	0	0	0	0	0	0	0	0	704	575	558	369	820	1,021
Education & training	221	134	261	194	255	0	0	0	0	0	0	0	0	0	58	1,518	39	156	125	289	10,617	9,208	12,700
Planning & management	6,043	0	301	138	91	194	170	47	0	0	0	0	0	0	0	0	0	1,353	420	2,659	0	73	743
Irrigation	7,227	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,413	1,477	3,337	0	0	0
Marketing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	7,715	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,531	1,126	2,016	310	1,519	1,213	0
Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fisheries	820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	508	155	0	157	0
Rural development	94,235	31,243	778	12,335	88	0	29,578	0	5,492	0	0	0	1,458	367	0	222	11,309	565	0	0	3	0	802
Infrastructure	91,907	31,243	778	12,335	88	0	29,578	0	5,492	0	0	0	1,458	0	0	0	10,934	0	0	0	0	0	0
Health & population	1,038	0	0	0	0	0	0	0	0	0	0	0	0	367	0	0	375	296	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water supply	802	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	802
Community development	488	0	0	0	0	0	0	0	0	0	0	0	0	0	0	222	0	269	0	0	3	0	0
Other	30,154	1,245	2,647	3,136	3,738	2,389	843	191	275	266	255	225	189	153	663	2,680	4,248	2,7Z9	796	0	0	232	3,205
PL 480 Food Aid	19,827	160	160	157	152	152	148	569	137	1,596	509	225	1,136	1,213	2,485	1,093	1,895	1,930	1,016	2,483	1,519	700	391
Other economic assistance	44,455	1,925	3,201	2,511	2,734	1,819	1,183	1,139	1,373	1,330	1,782	1,575	1,704	1,907	1,491	1,873	2,333	2,831	2,483	2,483	2,431	2,000	7
Total	**271,390**	**34,795**	**8,163**	**19,617**	**7,138**	**5,002**	**32,092**	**1,993**	**7,278**	**3,191**	**2,546**	**2,026**	**4,488**	**3,640**	**5,467**	**7,806**	**21,868**	**14,670**	**10,61O**	**13,078**	**19,479**	**21,700**	**24,745**

Source: Johnson et al. (1988).

Table 3. Sectoral Breakdown of U.S. Assistance to Kenya, by Year, 1963–84
(in thousands of constant 1983 dollars)

Sector/Subsector	Total	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ASD Project and Program Assistance	519,418	21,361	10,141	17,756	11,876	10,911	18,684	6,852	7,401	13,335	5,369	27,613	3,647	21,295	13,384	52,984	48,091	22,815	34,991	21,681	45,920	60,168	44,038
Agriculture	269,296	8,348	3,883	3,249	3,435	3,050	3,890	2,901	3,444	2,372	2,487	24,768	2,015	19,409	10,727	14,814	44,514	17,304	32,689	18,750	19,760	12,404	15,083
Crop production	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage & processing	8,070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,070	0	0	0
Input supply	89,603	0	0	0	0	0	0	0	0	0	0	22,506	0	0	5,798	5,508	4,049	1,708	16,471	6,26,4	14,585	0	12,715
Credit	5,504	234	765	493	0	0	0	0	0	178	794	347	407	480	1,067	614	176	19	0	0	31	0	0
Research	5,801	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,767	959	0	1,013	0	1,062
Extension	2,604	0	189	226	267	200	376	344	464	298	239	0	0	0	0	0	0	0	0	0	0	0	0
Education & training	80,531	5,499	826	571	960	1,137	881	1,278	1,552	806	649	1,087	691	699	1,002	966	37,574	5,662	4,515	3,052	7,698	5,077	0
Planning & management	27,533	0	0	364	49	367	813	296	228	186	224	0	0	66	1,617	1,180	1,152	6,312	5,855	0	41	7,563	1,302
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marketing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	43,743	2,615	3,755	1,563	2,068	1,234	1,665	897	1,085	880	580	828	916	18,165	1,243	6,546	1,563	875	959	0	3,463	236	4
Forestry	5,294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,930	1,364	0	0	0
Fisheries	613	0	0	31	91	112	154	85	115	24	0	0	0	0	0	0	0	0	0	0	0	0	0
Rural development	135,855	1,524	4,254	4,149	3,241	591	11,260	951	1,269	9,667	1,754	1,488	1,206	1,666	2,657	36,709	3,350	5,510	1,813	2,052	14,800	17,936	8,008
Infrastructure	48,420	0	0	0	425	0	10,648	0	5,492	0	0	0	1,458	520	0	35,126	729	643	393	0	0	64	0
Health & population	27,736	0	0	0	0	0	0	379	450	375	1,245	349	634	496	2,268	1,566	1,971	4,841	1,392	1,987	13,508	3,330	7,054
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Community development	29,024	1,524	4,254	4,149	2,816	591	612	572	818	9,292	509	1,139	572	650	389	17	650	26	28	65	279	70	0
Industry	30,675	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,013	14,600	15,062
Other	114,267	11,489	2,004	10,358	5,200	7,270	3,535	3,000	2,689	1,295	1,128	1,357	426	220	0	562	227	0	493	879	11,360	29,826	20,946
PL 480 Food Aid	181,184	2,246	1,280	12,241	44,650	2,425	2,366	285	2,197	3,723	1,273	900	947	1,733	3,976	2,342	1,166	1,544	21,784	26,280	17,623	16,900	13,302
Other economic assistance	135,071	0	320	3,453	4,556	2,729	4,732	4,270	15,654	27,393	6,618	5,852	4,923	6,240	4,970	6,713	12,829	4,633	3,838	3,518	3,038	4,000	4,793
Total economic assistance	835,673	23,607	11,742	33,450	61,082	16,065	25,783	11,407	25,252	44,451	13,260	34,365	9,517	29,268	22,330	61,139	62,087	28,992	60,617	51,479	66,582	81,068	62,132
Military assistance	245,313	0	0	0	0	0	0	0	0	0	0	0	0	8,666	51,192	23,729	39,946	13,383	23,364	6,725	33,525	21,700	23,083
Total	**1,080,987**	**23,607**	**11,742**	**33,450**	**61,032**	**16,065**	**25,783**	**11,407**	**25,252**	**44,451**	**13,260**	**34,365**	**9,517**	**37,934**	**73,522**	**84,868**	**102,033**	**42,375**	**83,981**	**58,204**	**100,106**	**102,768**	**85,215**

Source: Johnson et al. (1988).

Table 4. Sectoral Breakdown of U.S. Assistance to Malawi, by Year, 1963–84
(in thousands of constant 1983 dollars)

Sector/Subsector	Total	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ASD Project and Program Assistance	146,732	132	672	14,479	6,536	4,526	3,363	3,521	19,910	266	685	25,133	261	23,316	2,459	3,005	144	4,875	4,946	6,181	7,519	7,079	7,424
Agriculture	25,517	0	0	4,429	1,209	806	731	1,136	0	0	318	542	0	0	2,394	2,888	13	4,244	1,860	2,794	2,180	0	0
Crop production	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage & processing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Input supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Credit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research	10,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,217	1,860	2,794	2,180	0	0
Extension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education & training	15,467	0	0	4,429	1,209	806	731	1,136	0	0	318	542	0	0	2,394	2,888	13	1,027	0	0	0	0	0
Planning & management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marketing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fisheries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rural development	84,114	132	0	1,315	1,112	418	287	102	19,773	0	28	21,541	0	23,226	0	0	0	507	1,393	1,993	2,906	4,354	5,076
Infrastructure	69,128	0	0	1,014	1,002	109	195	85	19,773	0	31	21,541	0	23,226	0	0	0	0	0	0	0	0	2,152
Health & population	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water supply	6,186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	790	1,759	2,906	731	0
Community development	3,312	0	0	301	109	218	92	17	0	0	0	0	0	0	0	0	0	507	603	234	0	795	435
Industry	5,489	132	0	0	0	91	0	0	0	0	51	0	0	0	0	0	0	0	0	0	0	2,828	2,489
Other	37,101	0	672	8,735	4,216	3,302	2,346	2,283	137	266	387	3,050	261	90	65	117	157	124	1,693	1,395	2,734	2,725	2,347
PL 480 Food Aid	12,168	0	0	314	0	0	0	285	0	266	2,036	675	189	693	663	781	292	257	1,242	3,000	101	200	1,174
Other economic assistance	31,984	1,283	4,482	3,767	4,556	3,335	2,662	2,562	1,922	1,064	764	450	379	347	331	0	0	515	451	621	912	800	782
Total	**1,080,987**	**23,607**	**11,742**	**33,450**	**61,032**	**16,065**	**25,783**	**11,407**	**25,252**	**44,451**	**13,260**	**34,365**	**9,517**	**37,934**	**73,522**	**84,868**	**102,033**	**42,375**	**83,981**	**58,204**	**100,106**	**102,768**	**85,215**

Source: Johnson et al. (1988).

Table 5. Sectoral Breakdown of U.S. Assistance to Nigeria, by Year, 1963–84
(in thousands of constant 1983 dollars)

Sector/Subsector	Total	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ASD Project and Program Assistance	943,020	86,946	145,969	86,630	70,468	65,485	63,001	124,114	109,025	86,700	63,384	23,857	6,627	11,786	0	948	168	142	0	0	0	0	0
Agriculture	284,233	67,553	17,230	76,256	32,333	17,053	15,259	11,896	11,518	10,388	7,527	8,820	3,191	6,184	0	821	155	0	0	0	0	0	0
Crop production	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage & processing	3,981	1,211	312	1,758	217	17O	176	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Input supply	79	0	0	55	7	15	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Credit	3,249	433	134	508	401	464	254	182	187	290	395	0	0	0	0	0	0	0	0	0	0	0	0
Research	14,341	1,523	992	2,470	1,681	998	844	330	391	523	925	1,348	489	2,451	0	623	0	0	0	0	0	0	0
Extension	35,972	8,874	3,509	7,128	3,651	2,150	2,085	3,097	2,558	1,780	1,314	173	0	0	0	0	0	0	0	0	0	0	0
Education & training	135,971	36,229	7,206	34,751	14,266	5,470	5,143	4,272	5,627	5,402	3,787	7,735	2,702	3,733	0	198	155	0	0	0	0	0	0
Planning & management	26,811	3,301	803	4,715	5,993	3,303	3,115	1,810	1,362	1,630	868	90	0	0	0	0	0	0	0	0	0	0	0
Irrigation	23,227	4,630	762	9,729	2,934	1,962	1,532	632	533	2TT	237	0	0	0	0	0	0	0	0	0	0	0	0
Marketing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	38,499	10,479	3,469	14,398	2,986	2,289	2,094	1,435	860	487	3	0	0	0	0	0	0	0	0	0	0	0	0
Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fisheries	2,104	873	42	744	197	233	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rural development	36,087	20,373	0	0	0	0	0	7,971	0	0	0	5,627	0	2,115	0	126	13	142	0	0	0	0	0
Infrastructure	23,344	20,373	0	0	0	0	0	7,971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health & population	7,743	0	0	0	0	0	0	0	0	0	0	5,627	0	2,115	0	126	13	142	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Community development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industry	5,489	132	0	0	0	91	0	0	0	0	51	0	0	0	0	0	0	0	0	0	0	2,828	2,489
Other	623,680	0	128,739	10,374	38,135	48,431	47,742	104,247	97,508	76,312	55,857	9,410	3,437	3,487	0	0	0	0	0	0	0	0	0
PL 480 Food Aid	182,541	963	1,921	3,139	1,822	2,122	6,211	120,129	22,794	11,702	509	900	5,680	3,967	663	0	0	0	0	0	0	0	0
Other economic assistance	82,878	8,663	15,365	13,497	19,439	13,643	6,803	3,701	824	266	0	0	0	347	331	0	0	0	0	0	0	0	0
Total	**1,208,439**	**96,572**	**163,255**	**103,265**	**91,730**	**81,249**	**76,016**	**247,944**	**132,643**	**98,668**	**63,893**	**24,757**	**12,308**	**16,119**	**994**	**948**	**168**	**142**	**0**	**0**	**0**	**0**	**0**

Source: Johnson et al. (1988).

Table 6. Sectoral Breakdown of U.S. Assistance to Senegal, by Year, 1963–84
(in thousands of constant 1983 dollars)

Sector/Subsector	Total	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ASD Project and Program Assistance	174,311	7,058	6,722	314	1,822	910	887	854	549	266	255	225	189	10,920	1,822	13,582	12,684	19,303	11,287	15,313	16,408	19,100	33,841
Agriculture	114,716	645	547	1,271	1,221	52	240	17	0	0	0	0	0	9,677	1,473	11,865	9,581	9,582	9,909	13,161	13,754	13,083	18,775
Crop production	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage & processing	9,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,650	0	0	0	0	0	0	2,201
Input supply	15,255	0	352	22	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,000	9,781
Credit	1,477	0	0	0	0	0	0	0	0	0	0	0	0	116	16	0	271	183	169	135	147	200	239
Research	4,697	0	0	0	0	0	0	0	0	0	0	0	0	466	65	0	560	396	339	788	283	400	1,401
Extension	26,420	0	435	56	738	0	0	0	0	0	0	0	0	4,947	689	656	2,611	2,198	2,923	2,768	3,962	2,595	1,955
Education & training	11,762	645	240	75	267	0	0	0	0	0	0	0	0	291	41	0	2,605	105	1,196	1,197	2,846	2,280	453
Planning & management	15,070	0	0	0	115	52	0	17	0	0	0	0	0	0	0	0	2,204	1,405	1,422	2,404	3,897	1,650	2,010
Irrigation	9,510	0	0	1,230	0	0	240	0	0	0	0	0	0	0	0	3,559	1,330	0	793	1,128	0	494	736
Marketing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	15,969	0	0	0	0	0	0	0	0	0	0	0	0	3,857	663	0	0	3,256	1,896	3,830	2,034	434	0
Forestry	4,319	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,807	1,170	755	586	0	0
Fisheries	387	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	232	0	155	0	0	0
Rural development	13,385	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,240	1,790	2,513	206	227	91	475	6,842
Infrastructure	6,602	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	6,602
Health & population	6,681	0	0	0	0	0	0	0	0	0	0	5,627	0	2,115	0	1,240	1,790	2,449	206	230	91	435	240
Education	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	2	0	0	0
Water supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Community development	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0
Other	46,210	6,414	6,175	957	601	961	648	871	549	266	255	225	189	1,243	350	478	1,312	7,208	1,172	1,924	2,562	5,542	8,224
PL 480 Food Aid	192,713	1,925	8,003	2,511	3,949	16,977	4,437	5,978	9,337	6,915	2,800	3,601	14,958	3,640	3,810	4,527	16,326	7,592	17,043	19,244	12,458	12,300	14,378
Other economic assistance	61,545	2,246	2,881	2,197	2,430	1,819	2,366	1,993	1,648	1,596	1,782	1,801	1,515	1,733	1,822	2,342	2,333	2,316	2,145	2,173	2,026	1,800	18,583
Total	**428,569**	**11,229**	**17,606**	**5,022**	**8,201**	**19,706**	**7,690**	**8,825**	**11,534**	**8,776**	**4,837**	**5,627**	**16,663**	**16,293**	**7,455**	**20,451**	**31,345**	**29,212**	**30,475**	**36,7330**	**30,891**	**33,200**	**66,803**

Source: Johnson et al. (1988).

Table 7. Sectoral Breakdown of U.S. Assistance to Tanzania, by Year, 1963–84
(in thousands of constant 1983 dollars)

Sector/Subsector	Total	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ASD Project and Program Assistance	341,474	14,505	13,307	35,747	10,974	13,849	12,958	3,259	26,185	17,715	4,938	21,575	11,685	28,833	14,610	10,642	25,138	26,373	16,482	22,408	10,588	180	119
Agriculture	126,292	4,306	515	4,918	984	564	1,612	327	2,186	7,758	3,156	2,762	9,414	26,938	8,133	8,827	12,283	15,172	6,487	2,699	5,947	180	1,483
Crop production	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage & processing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Input supply	43,16,4	0	0	0	0	0	0	0	665	311	438	585	4,900	23,550	3,897	2,167	2,592	3,481	593	0	0	14	0
Credit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research	14,866	0	0	0	0	0	0	0	0	141	873	545	206	385	470	1,088	2,063	3,198	1,467	1,391	3,038	0	0
Extension	6,852	1,790	439	596	510	82	0	0	0	0	0	0	0	0	0	0	3,435	0	0	0	0	0	0
Education & training	32,153	2,515	77	4,322	474	388	639	105	0	0	0	0	784	877	1,296	2,448	1,924	6,061	4,427	1,309	3,024	0	1,483
Planning & management	5,183	0	0	0	0	94	973	222	1,055	1,218	1,067	576	0	0	0	0	22	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marketing	3,217	0	0	0	0	0	0	0	0	1,080	71	223	339	789	181	492	159	0	0	0	115	0	0
Livestock	20,857	0	0	0	0	0	0	0	467	5,008	708	833	3,185	1,338	2,290	2,632	2,131	2,432	0	0	0	166	0
Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fisheries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rural development	157,636	7,241	6,642	11,852	2,330	6,400	6,510	458	21,385	8,585	1,166	17,924	2,206	889	6,358	1,817	12,i3G	11,201	9,992	19,490	4,641	0	1,602
Infrastructure	77,823	4,687	6,076	10,279	1,233	5,881	2,783	14	21,286	8,585	1,186	11,028	0	3	4,771	0	0	0	0	83	75	0	0
Health & population	38,197	0	0	0	0	0	0	0	0	0	0	6,896	2,206	886	1,587	1,795	2,152	8,228	3,742	12,219	9	0	1,504
Education	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Community development	8,885	2,554	567	1,573	671	518	893	444	44	0	0	0	0	0	0	22	15	515	11	1,137	19	0	98
Industry	32,731	0	0	0	425	0	2,834	0	55	0	0	0	0	0	0	0	9,963	2,485	6,239	6,051	4,706	0	0
Other	57,547	2,958	6,149	18,977	7,660	6,885	4,836	2,474	2,614	1,372	596	889	64	1,005	119	2	726	0	3	219	0	0	0
PL 480 Food Aid	247,723	9,625	5,122	6,278	9,416	6,063	7,986	5,693	4,943	6,915	3,055	3,601	4,923	40,905	45,890	27,944	11,663	3,088	11,287	15,313	7,698	6,500	3,814
Other economic assistance	56,112	963	4,802	7,847	6,379	4,851	2,662	854	0	0	0	0	0	0	0	468	20,119	257	339	2,433	1,418	1,400	1,271
Total	**645,309**	**25,093**	**23,230**	**49,872**	**26,769**	**24,763**	**23,606**	**9,807**	**31,129**	**24,630**	**7,993**	**25,176**	**16,608**	**69,738**	**60,501**	**39,055**	**56,920**	**29,719**	**28,108**	**40,204**	**19,704**	**7,720**	**4,967**

Source: Johnson et al. (1988).

Table 8. USAID Agricultural Research Appropriations, 1978–1981, by Subcategory[1]
(in thousands)

	FY 1978 Actual			FY 1979 Actual			FY 1980 Actual			FY 1981 Actual		
	Ag/Rur Dev., & Nut.	*Sahel Dev.*	*Econ. Support*	*Ag., Rur. Dev., & Nut.*	*Sahel Dev.*	*Econ. Support*	*Ag., Rur. Dev., & Nut.*	*Sahel Dev.*	*Econ. Support*	*Ag., Rur. Dev., & Nut.*	*Sahel Dev.*	*Econ. Support*
1. Agricultural technology—Research by U.S. institutions[2]												
Africa	—	—	—	2,756	—	—	—	—	—	2,000	350	—
Asia	117	—	—	1,040	—	—	—	—	—	—	—	—
Latin America & the Caribbean	1,100	—	—	1,511	—	—	700	—	—	1,051	—	—
Near East	150	—	—	1,200	—	—	4,032	—	—	6,451	—	—
Development support	20,244	—	—	21,315	—	—	19,104	—	—	15,058	—	—
Totals	*21,611*	—	—	*27,822*	—	—	*22,836*	—	—	*24,560*	—	—
2. International Centers[3]												
Africa	—	—	—	—	—	—	—	—	—	—	—	—
Asia	—	—	—	—	—	—	—	—	—	—	—	—
Latin America & the Caribbean	10,000	—	—	—	—	—	—	—	—	—	—	—
Near East	—	—	—	—	—	—	—	—	—	—	—	—
Development support	21,652	—	—	29,758	—	—	33,800	—	—	40,000	—	—
Totals	*31,652*	—	—	*29,758*	—	—	*33,800*	—	—	*40,000*	—	—
3. Agricultural technology—LDC research[4]												
Africa	10,597	5,374	—	24,454	5,373	—	22,944	5,642	—	33,356	6,050	366
Asia	920	—	—	6,042	—	—	9,000	—	—	30,600	—	—
Latin America & the Caribbean	8,645	—	—	20,569	—	—	2,165	—	—	8,636	—	—
Near East	2,896	—	—	1,456	—	6,471	1,115	—	—	—	—	22,000
Development support	—	—	—	—	—	—	—	—	—	—	—	—
Totals	*23,058*	*5,374*	—	*52,521*	*5,373*	*6,471*	*35,224*	*5,642*	—	*72,592*	*6,050*	*22,166*
Total agricultural research												
Africa	10,197	5,374	—	27,210	5,373	—	22,944	5,642	—	35,356	6,400	—
Asia	1,037	—	—	7,082	—	—	9,000	—	—	30,600	—	—
Latin America & the Caribbean	19,745	—	—	22,080	—	—	2,865	—	—	9,867	—	—
Near East	3,014	—	—	2,656	—	6,471	5,147	—	—	6,451	—	22,366
Development support	45,315	—	—	51,073	—	—	52,904	—	—	55,158	—	—
Totals	*79,328*	*5,374*	—	*110,101*	*5,373*	*6,471*	*92,860*	*5,642*	—	*137,252*	*6,400*	*22,366*
Total USAID Appropriation for Agriculture, Rural Development, and Nutrition												
Africa	97,229	49,846	160,051	97,906	74,453	51,000	102,713	76,474	132,690	105,114	95,661	164,500
Asia	228,492	—	—	296,338	—	—	278,989	—	22,000	287,466	—	32,000
Latin America & the Caribbean	196,101	—	—	129,741	—	8,000	147,365	—	15,225	127,934	—	150,175
Near East	19,814	—	2,103,787	19,960	—	1,881,252	14,812	—	1,987,126	27,065	—	1,921,950
Development support	63,778	—	—	73,664	—	—	75,763	—	—	77,815	—	—
Totals	*610,331*	*49,846*	*2,261,839*	*614,856*	*74,453*	*1,942,342*	*630,834*	*76,474*	*2,157,050*	*641,746*	*95,661*	*2,220,825*

1. Source: U.S. Agency for International Development. Office of Planning and Budgeting (PPC/PB). Figures as of July 27, 1981.
2. Functional subcategory "FNDR"—Activities financing direct research in agricultural technology by U.S. institutions.
3. Functional subcategory "FNIC"—Activities financing international agricultural research centers. Includes appropriations for ICLARM, the International Center for Living Aquatic Resources Management, located in the Philippines ($300,000 in 1979, $200,000 in 1980, and $100,000 in 1981).
4. Functional subcategory "FNDS"—Activities financing direct agricultural research by LDC institutions.
5. Totals may not add because miscellaneous items are omitted.

Table 9. Comparative Expenditures on Agricultural Research — Sub-Saharan Africa and Other Regions

Agricultural Research Expenditures
(millions of 1980 US Dollars)
with Expenditures as a Percentage of AGGDP in Brackets

Region	1960–64	%	1965–69	%	1970–74	%	1975–79	%	1980–85	%	1980–85: 1960–64
Sub-Saharan Africa	120.879	(0.25)	202.817	(0.41)	267.161	(0.44)	347.858	(0.55)	381.940	(0.54)	3.2
Asia & Pacific	238.337	(0.12)	395.226	(0.17)	598.826	(0.22)	810.699	(0.27)	1105.523	(0.34)	4.6
Latin America & Caribbean	179.386	(0.24)	251.788	(0.31)	447.231	(0.41)	656.884	(0.53)	714.349	(0.54)	4.0
West Asia & North Africa	110.652	(0.25)	163.024	(0.31)	304.837	(0.47)	362.832	(0.53)	344.048	(0.43)	3.1
Developed Countries	2020.762	(0.89)	2955.308	(1.26)	3656.655	(1.42)	4090.2-31	(1.58)	4717.398	(2.01)	2.3

In this table as in others on expenditure, the purchasing power parity indices have been used to convert to U.S. dollars.

Source: Calculation based on data summarized in Pardey and Roseboom (1989a).

Table 10. Expenditures on Agricultural Research in Sub-Saharan African Countries
(Average, 1980–85)

Country	Expenditures (millions of 1980 U.S. Dollars)	Expenditures per Researcher	Expenditures (as % of Agricultural GDP)
Angola	4.335	(?)→ 15,4816	0.24
Benin	2.383	54,993	0.32
Botswana	5.849	113,634	4.24
Burkina Faso	15.568	134,029	1.74
Burundi	4.381	74,251	0.52
Cameroon	15.069	92,163	0.74
Cape Verde	0.320	22,860	1.23
Central African Republic			
Chad	1.481		0.33
Comoros			
Congo	2.494	33,703	1.34
Côte d'Ivoire	28.330	141,625	1.09
Ethiopia	11.323	94,053	0.21
Gabon	2.494	103,925	
Gambia			
Ghana	3.344	25,821	0.11
Guinea	5.605	31,667	0.66
Guinea-Bissau	0.907	113,345	0.68
Kenya	28.397	67,927	0.87
Lesotho	6.043	335,726	3.38
Liberia	5.247	166,672	2.81
Madagascar	7.318	107,016	0.38
Malawi	4.902	59,778	0.52
Mali	12.552	45,645	1.18
Mauritania	0.501		0.18
Mauritius	5.546	53,616	2.79
Mozambique			
Noger	1.994	33,771	0.19
Nigeria	92.393	91,958	0.59
Rwanda	2.004	65,668	0.23
Sao Tome and Principe	0.164	81,846	0.74
Senegal	13.206	93,275	1.54
Seychelles			
Sierra Leone	0.946	15,405	0.22
Somalia	0.322	9,476	0.03
Sudan	13.683	74,863	0.31
Swaziland	2.472	348,740	1.87
Tanzania	20.417	54,133	0.64
Togo	6.174	138,808	1.46
Uganda			
Zaire	3.820	93,259	0.19
Zambia	3.576	37,942	0.69
Zimbabwe	17.448	115,941	1.91
Sub-Saharan Africa total	**381.940**	**78,340**	**0.54**

Source: Calculation based on data summarized in Pardey and Roseboom (1989a).

Table 11. Resources of Scientific Manpower for Scientific Research in Sub-Saharan Africa

	National Agricultural Research Service research staff (B.S. and higher), 1980–86 (number and percentage/average)				Scientists with postgraduate M.Sc. & Ph.D. orequiv. degrees at inst. of higher agri. educ., 1980–86
			Postgraduates		
Western Africa	**Total researchers**	**% expatriates**	**% of total researchers**	**% nationals**	
Benin	45	7	73	71	26
Burkina Faso	114	48			42
Cameroon	187	33			
Cape Verde	16	19	57	45	0
Chad	28	29		28	
Côte d'Ivoire	201	73			59
The Gambia	62	27			0
Ghana	138	6	74	69	142
Guinea	177				
Guinea-Bissau	8	13	75	71	0
Liberia	33	27	69	57	31
Mali	275	11	29	20	66
Mauritania	12		92		0
Niger	57	56			18
Nigeria	1,005				637
Senegal	174	29			56
Sierra Leone	46				65
Toto	49	24			21
Subtotal	*2,626*	*31*	*50*	*29*	*1,191*
Central Africa					
Burundi	53	43	85	73	17
Central African Republic	NA				11
Congo	68	46			51
Gabon	24	58	71	30	10
Rwanda	34	28			8
Sao Tome and Principe	3				0
Zaire	43		23	124	
Subtotal	*225*	*43*	*60*	*59*	*221*
Southern Africa					
Angola	23	46	46	0	
Botswana	50	56	73	38	0
Lesotho	18	50	67	33	0
Madagascar	83	12	48	40	36
Malawi	80	6	30	26	41
Mauritius	99		36		17
Mozambique	77	83	83	0	33
Swaziland	11	36	55	17	27
Zambia	111	49	61	24	21
Zimbabwe	153		45		32
Subtotal	*710*	*41*	*52*	*24*	*207*
Eastern Africa					
Comoros	14	50	50	0	0
Ethiopia	142	643	40	68	
Kenya	483	16	45		242
Seychelles	7	38	38	0	0
Somalia	31	13	9		57
Sudan	206		81		164
Tanzania	276	22	61	49	168
Uganda	168				56
Subtotal	*1,326*	*17*	*54*	*44*	*755*
Total	**4,888**	**29**	**53**	**38**	**2,374**

Source: Calculation based on data summarized Pardey and Roseboom (1989a). Gaps in columns indicate information not available.

Table 12. National Agricultural Research Institutions in French-Speaking Countries of West and Central Africa, 1987

Country	Year	Institution	Mandate	Affiliation
Mali	1960	Instit d'Economie Rurale (IER)	Crop production	Department of Agriculture*
Mali	1960	Institut National de la Recherche Zootechnique, Forestiere et Hydro-biologique (INRZFH)	Animal production	Dept. of Forestry and Environment
Senegal	1961	Institut de Technologie Alimentaire (ITA)	Food technology	Department of Agriculture
Burundi	1962	Institut des Sciences Agronomiques du Burundi (ISABU)	Agricultural production, forestry	Department of Agriculture
Rwanda	1962	Institut des Sciences Agronomiques du Rwanda (ISAR)	Agricultural production, forestry	Department of Agriculture
Togo	1965	Institut National de la Recherche Scientifique (INRS)	Botany, social sciences	Department of Science
Togo	1968	Direction Nationale de Technologie Alimentaire (DNTA)	Food technology	Department of Agriculture
Zaire	1970	Institut National pour l'Etude et la Recherche Agronomiques (INERA)	Agricultural production	Department of Science
Côte d'Ivoire	1971	Centre Ivoirien de Recherches Economiques et Sociales (CIRES)	Social sciences, agricultural economics	University of Abidjan
Mauritania	1973	Centre National d'Etudes et de Recherches Veterinaries (CNERV)	Animal production	Department of Agriculture
Niger	1974	Institut National de la Recherche Agronomique (INRAN)	Agricultural production	Department ofAgriculture
Cameroon	1974	Institut de Recherche Agronomique (IRA)	Crop production	Department of Science
Cameroon	1974	Institut de Recherches Zootechniques (IRZ)	Animal production	Department of Science
Cameroon	1974	Institut des Services Humains (ISH)	Social science	Department of Science
Senegal	1975	Institut Senegalais de Recherches Agricoles (ISRA)	Agricultural production	Department of Agriculture
Togo	1976	Direction de la Recherche Agronomique (DRA)	Crop production	Department of Agriculture
Mauritania	1977	Laboratoire d'Entomologie Agricole (LEA).	Agricultural entomology	Department of Agriculture
Burkina Faso	1981	Institut d'Etudes et de Recherches Agricoles (INERA)	Agricultural production	Department of Science
Burkina Faso	1982	Institut de Recherche en Biologie et Ecologie Tropicale (IRBET)	Tropical ecology	Department of Science
Côte d'Ivoire	1982	Institut de Developement des Savannes (IDESSA)	Agricultural production	Department of Science
Benin	1984	Direction de la Recherche Agronomique (DRA)	Agricultural production	Department of Agriculture

*Department of Agriculture also stands as a proxy for other government departments having main responsibility for development of agriculture.

Source: Based on ISNAR Working Paper no. 21.

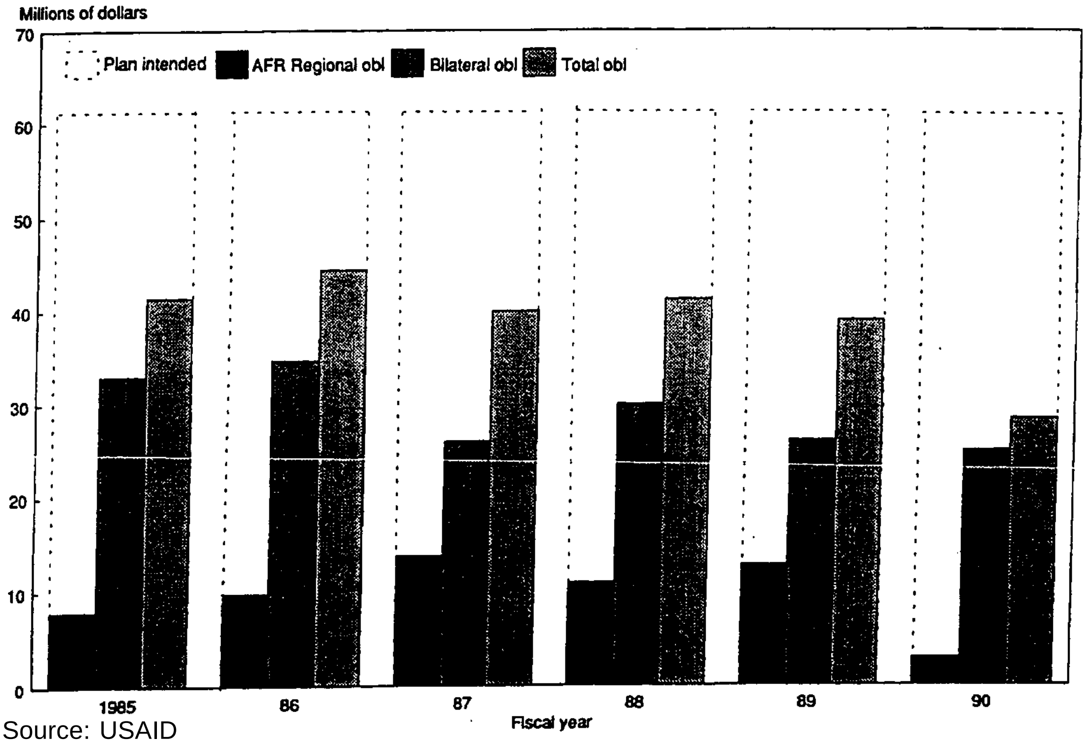
Table 13: Types of Agricultural Research Institutions in Anglophone Africa

Semiautonomous research councils	Council for Scientific and Industrial Research (CSIR), Ghana Agricultural Research Corporation (ARC), Sudan
Semiautonomous research institutes / organizations	Kenya Agricultural Research Institute, (KARI) * The Tanzanian Agricultural Research Organization (TARO) * The Tanzania Livestock Research Organization (TALIRO) Cameroon Institute of Agricultural Research (ISAR) Agricultural Research Institute, Ethiopia
Autonomous advisory and coordinating councils	National Council for Science and Technology (NCSI), Nigeria and Kenya National Research Council (NRC), Uganda National Council for Scientific and Industrial Research (NCSIR), Zimbabwe National Council for Scientific Research (NCSR), Zambia Agricultural Research Council (ARC), Zimbabwe
Departments of agricultural research in the ministries of agriculture	Department of Research and Specialist Services (DR&SS), Zimbabwe Agricultural Research Division, Lesotho Department of Agricultural Research, Botswana Department of Agricultural Research, Uganda Department of Agricultural Research, Zambia Department of Agricultural Research, Malawi Agricultural Research Institute, Somalia Department of Agricultural Research, Gambia
University faculties/institutes of agriculture	Ahmadu Bello University Institute of Agricultural Research (LAR), Nigeria Sokoine University of Agriculture (SUA), Tanzania University of Swaziland, Swaziland Obafemi Awolowo University, Ife Institute of Agricultural Research & Training (LAR&T), Nigeria

*Integrated into the Research and Training Division of the Ministry of Agriculture and Livestock Development in 1989.

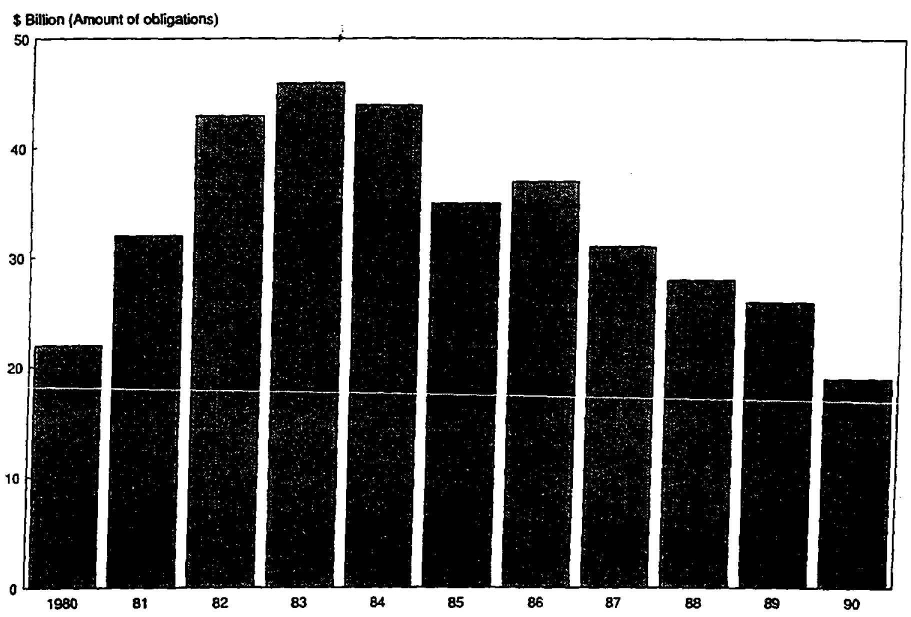
Source: Taylor (1988).

Figure 2. Actual and Intended Obligations for agricultural Research in Africa



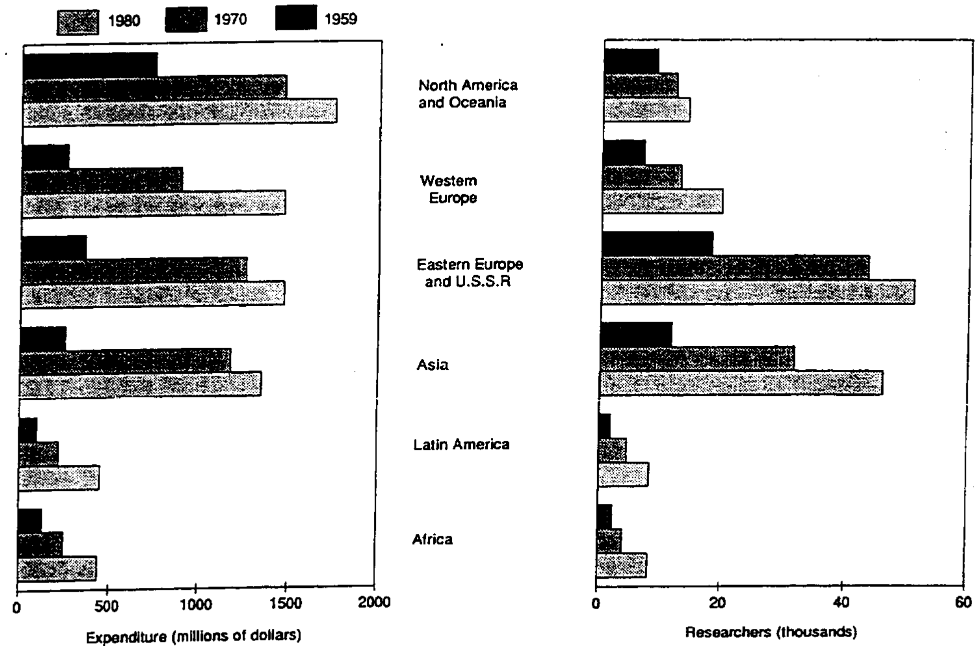
Source: USAID

Figure 3. Annual Obligations (Regional and Bilateral) for Agricultural Research in Africa



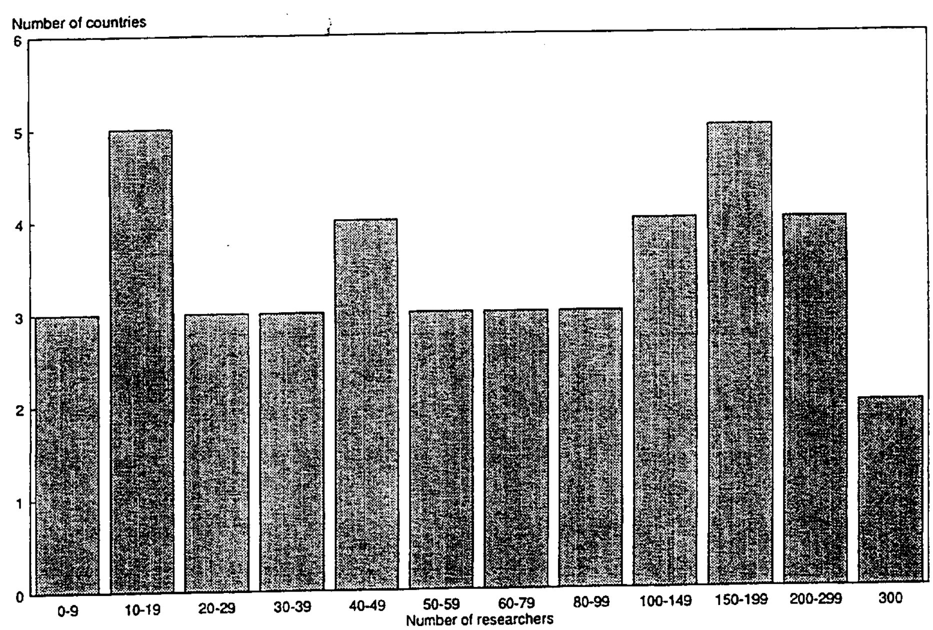
Source: USAID

Figure 4. Agricultural Research: Public Sector Expenditures and Staffing, by Region, 1959, 1970, and 1980



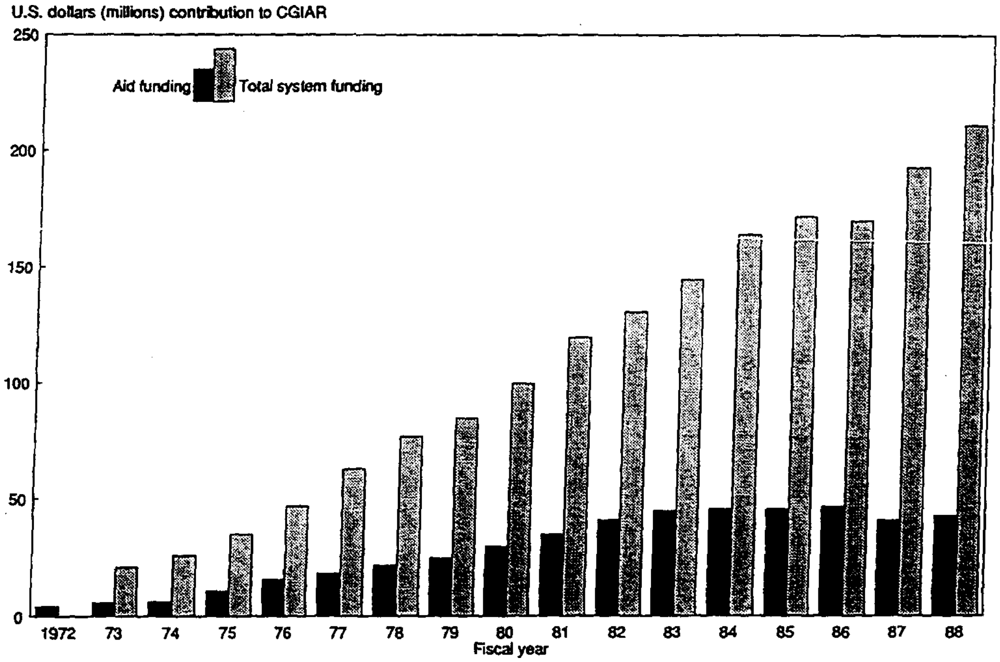
Source: Anderson, Herdt, and Scobi. Science and Food

Figure 5. Size Distribution by Number of Researchers of 42 Sub-Saharan NARSs, 1980-1986



Source: ISNAR data base

Figure 6. Core Contributions to International Agricultural Research Centers Sponsored by CGIAR



Source: USAID

3. Illustrative Examples of Success and Failure

It is now obvious that agricultural research in Africa has not produced the massive improvements in production and productivity associated with the Green Revolution in Asia. It is, however, too easy to jump from this fact to the conclusion that agricultural research in Africa is unproductive, has produced no genuine "success" stories, and is therefore a poor investment of increasingly scarce resources.

The collection of successes and failures analyzed below tell a different story. They indicate that there are a significant number of research results that have been widely disseminated and that have significantly impacted agricultural productivity. In virtually all cases, the successful spread of research findings is associated with both improvements in physical technology (better varieties, improved mechanical technology) and supportive markets. In the absence of established markets that provide farmers reliable expectations of cash earnings, it is uneconomical to invest in purchased inputs. This is the case even for such research successes as hybrid maize (for example, Malawi versus Kenya and Zimbabwe). Successful cases of research adoption in the absence of a cash market are relatively rare, and are associated with severe threats to household food security (for example, improved cassava varieties). Furthermore, poorly functioning markets—whether for inputs or for final products—have now been widely implicated in the untimely demise of many a promising research finding.

The successes and failures also suggest that there is more than one way to achieve supportive marketing systems. One, typified by cotton in francophone Africa, is to establish well run operations within a relatively controlled system. This appears to work as long as there is an effective mechanism for controlling costs and as long as the macroeconomic environment does not threaten the competitiveness of the system. A second, typified by informal markets in so-called "minor" crops (potatoes, beans, cassava), is to permit relatively local markets to operate without either impediment or investment. A third, typified by much of the policy reform impetus, is to create competitive private markets that can operate effectively on a national or regional basis. In many cases, this requires both new policies and new institutional and entrepreneurial capabilities.

The successes and failures also suggest that research designed to improve production *primarily* for subsistence consumption is likely to be very difficult. Micro (household) preferences are much more important in crops grown primarily for subsistence production, and it has proved very difficult for breeders to respond to these taste preferences effectively. In addition, relatively closed subsistence systems tend to be intricately balanced within relatively tight constraints. Finally, in many cases, researchers are finding that many rural households *are not* self-sufficient even in staple foods. Pressures of population growth and environmental degradation are likely to increase the number of poor households dependent on food purchases, while economic growth and enhanced employment opportunities may create opportunities for other rural households to purchase food on more favorable terms.

Maize

By far the most successful research program has been in maize. New maize technologies, both hybrids and composites, have had major impacts on production and productivity in East, West, and Southern Africa. The introduction and dissemination of hybrid maize in East Africa occurred first in Kenya and has had its greatest impact there. The breeding program that led to the breakthrough in hybrid maize began in 1955 at the Kitale station of the Kenyan Agricultural Research Institute (KARI). The breeding program, headed by Michael Harrison, began as an effort to develop late maturity maize hybrids for the commercial (then European) maize-growing region.[38] USAID was significantly involved in the Kenya maize breeding activity, although it was by no means the only institution supporting this activity. The research working leading to the development of H611 (the widely disseminated hybrid variety) was the result of work supported by the Rockefeller Foundation, building on earlier research work by Harrison. USAID became directly involved in 1963, after the 1961 discovery of H611, but slightly before its commercial release in 1964.

Subsequent breeding efforts succeeded in further increasing yields and in producing some varieties better adapted to specific climatic zones. The KARI research program produced varieties that raised yields by 30 percent or more compared with local varieties. Between 1964 and 1989, it developed and released 11 high-altitude hybrids.

The private sector played a crucial role in the diffusion of hybrid maize in Kenya. The Kenya Seed Company reproduced the seed, distributed it, and promoted it throughout the country through a network of private shopkeepers.[39] This effort was supported by a well organized marketing system and a viable system of government-supported prices. This policy and marketing environment provided farmers with an incentive to adopt the crop, as well as assuring the cash inflow necessary to finance the repeated purchase of hybrid seed.

High-yielding hybrids, adapted to various rainfall zones, have been widely adopted by both large and small farmers. Between 1964 and 1973, the area planted to hybrid maize in Kenya grew to an estimated 324,000 hectares, with a rate of diffusion higher than that of hybrid corn in the United States. By 1973, almost 70 percent of Kenya's farmers were using hybrids.[40]

While the success in adapting hybrid maize in Kenya has received significant attention, there has also been a successful research program to develop early maturing, more drought tolerant open-pollinated varieties.[41] In 1968, the Katumani research station released a new variety (Katumani Composite B), which had a shorter growing season, and more stable yields than the previously dominant variety (Machakos White). Adoption proceeded quickly, with 45 to 50 percent of the land in the semiarid district of Machakos planted to Katumani maize by the mid-1970s.

The impact of new maize technologies on Kenyan agriculture has been substantial. Over the past 30 years, maize production has kept pace with Kenya's high population growth rate. While areas planted to maize increased, maize accounted for a decreasing portion of cultivated area. Newer technologies permitted maize to expand into lower potential areas, which released higher potential areas for cash crops such as coffee and tea. A recent quantitative evaluation of the impact of the new maize varieties found that substantial gains as a result of the higher yields achieved. Production gains of over 700,000 tons per year are attributable to the improved maize varieties. This translates into an addition 231 calories per day for the Kenyan population and a 4.4 percent increase in agricultural gross domestic product (GDP).[42]

In Zimbabwe, yield increases have been impressive—increasing threefold in the commercial sector since the 1950s and doubling in the communal area. This development was based on the 1960 release of the SR 52 (hybrid) variety, which arose from Southern Rhodesia's agricultural research program.[43] All commercial maize production in Zimbabwe is now hybrid maize, with some 85 percent of the crop planted to SR 52. It is estimated that about 45 percent of the observed increases in maize yields in Zimbabwe between 1950 and 1980 was due to the development of hybrids.

In Malawi, however, the spread of improved maize varieties has not been so dramatic. It is estimated that less than 10 percent of the maize area is planted to hybrids. A major reason is that the commercial market for maize is limited, unlike that in Kenya and Zimbabwe, and the hybrid varieties are ill suited for household consumption and processing. The dent hybrids available do not allow the endosperm to be separated out by pounding. Hybrid grain, therefore, is rarely processed locally and must be sold to government agencies. Small farmers grow their own varieties, which they can easily process.

Improved maize technology has had a significant impact in West Africa. In West Africa, maize has traditionally been a “minor” crop—in sharp contrast with its role as the dominant cereal in East and Southern Africa. Over the past two decades, however, improved maize technology—combined with favorable prices and the development of animal traction—led to a rapid increase in maize production and consumption, primarily at the expense of low value grains such as millet and sorghum. The area devoted to maize production more than doubled between 1970 and 1991, while average annual maize yields increased 67 percent.[44] The greatest increases occurred in the 1980s. During this period, Senegal had a 2.8 percent annual increase in maize production, about equal to its population growth rate, and higher than the growth rate other food staples and cash crops.[45]

Maize production based on improved (primarily open pollinated) varieties was profitable for Senegalese farmers; new maize varieties provided higher returns to land and labor than millet and sorghum, and provided a 30 percent greater return to labor than traditional maize varieties.[46] Adoption was particularly impressive in the Sine Saloum region, where a high level of merchant activity made commercial sales easier, and where extension agents worked closely with farmers to establish effective recommendations for fertilizer applications. In this region, maize area rose from virtually nothing in 1970–75 to an annual average of 30,000 hectares in 1985–90. Maize production was 41,000 metric tons a year higher, with a annual market value of almost 3 billion FCFA.[47] The Casamance also saw significant increases in area (from 17,000 hectares in 1970–75 to 40,000 in 1985–90). This translated into an annual production increase of 34,000 metric tons, worth 2.4 billion FCFA.[48]

While impacts were greatest in these two regions, there was a noticeable national impact. The improved maize technology was estimated to produce 80 million metric tons a year more maize than would have been produced if traditional varieties had been planted on the increased maize area. This additional production added 57 calories per day to per capita calorie consumption and reduced imports by about $7 million.[49]

Maize research in Nigeria dates primarily from the USAID-funded Major Cereals Project in the 1960s.[50] IITA and the Institute for Agricultural Research and Training (IRA&T) in Ibadan have been the leading institutions in Nigerian maize research. Work initially focused on the South (where maize was an established crop) and was extended to the savannah regions in the 1970s when on-farm trials demonstrated that improved maize varieties substantially outperformed both local and improved sorghum and millet.

High-yielding open-pollinated varieties (TAB, TZBP) have been available in Nigeria since 1973 and have been widely adopted. Hybrids have been developed, but have not been as widely adopted. A recent study estimated that 90 percent of the maize area in Nigeria is planted to improved maize varieties.[51]

Dissemination and adoption of improved varieties was facilitated by the large Agricultural Development Projects (ADPs) sponsored by the World Bank. Improved maize was one of the packages included in the projects, which also provided extension services and inputs. Government policy supported the expansion of maize production by providing subsidized inputs, although the performance of fertilizer and seed parastatals was poor, and farmers did not often get the inputs they required in a timely fashion.

The adoption of improved maize varieties has had significant national and regional impacts. Regionally, in the savanna zone, the new varieties *combined with* the availability of established markets in the south, contributed to the dramatic expansion production from subsistence levels (less than 10 percent of Nigeria's corn production) to 60 percent of national production. The bulk of this increase was due to new varieties. The additional production was estimated to provide an additional $165 million annual income for savanna farmers.[52] At the national level, improved technologies, which permitted expanded area, and increased yields led to an additional 987,000 metric tons of maize production—or a 31 calories per day increase in per capita food consumption.[53]

Hybrid maize varieties from Zimbabwe have also spread into West Africa. Cameroon has recently begun planting hybrid varieties from Zimbabwe (especially SR 52), with good results on the Adamaoua Plateau.[54] In addition, there appears to be selective adoption of several improved maize varieties in Cameroon, most associated with USAID-supported research.[55] There has been rather significant adoption of an improved maize variety (TZPB) in the South East Benoue Region of North Province, Cameroon. The variety provided yield increases of 1.8 tons per hectare (or 113 percent) among the farmers adopting it. The farmers in these areas grow cotton, with the Cameroon Cotton Development Company (SODECOTON) providing inputs and technical assistance. The improved maize variety was introduced to these farmers through the SODECOTON system between 1982 and 1885. The area planted to maize increased by 2,242 hectares (132 percent), maize production rose by 394 percent. The estimated value of the production increase is 108,000 FCFA per hectare.[56]

Adoption of the mid-altitude maize variety (Shaba) was also reported in the Adamaou Plateau. This variety, the first improved variety released in the Adamoau Plateau, was developed by a USAID-sponsored project in Shaba Province, Zaire, in 1988. The variety was released in 1987, with seed multiplication efforts currently underway by both public and private agencies. Several other promising varieties have been selectively distributed, but inadequate production of seed and packages has limited their dissemination (CMS 8501, Kasai I). The former variety is particularly interesting, since it reportedly yields about 40 percent more than unimproved local varieties without fertilizer.[57]

Maize cultivation, using improved varieties and chemical fertilizer, has also been relatively successful in southern Mali, where intensification of millet and sorghum has not. Again, the differences appear to reflect an interaction between physical factors (for example, the responsiveness of varieties to fertilizer) and economic and marketing considerations. Sales outlets for maize were relatively secure and provided the opportunity for cash income to cover the costs of fertilizer. Millet and sorghum markets were thinner and less reliable, and the low prices received for the crop made in uneconomical to apply fertilizer.[58]

Cotton

The successful adoption of research, reflected in both varieties planted and inputs used, has been a hallmark of cotton production in francophone Africa. By and large, cotton production in francophone Africa has been more successful than in anglophone countries (with the exception of Zimbabwe). A comparison of 14 francophone countries and 15 anglophone countries found that the francophone group, which started producing cotton only in commercial scale only in the early 1960s, has overtaken the anglophone group, which has shown slow or declining growth. The major reason is that yields are higher in francophone countries as a result of the higher (more intensive) technology used in francophone countries.[59]

A recent analysis of African cotton production concludes that the adoption of improved varieties and modern input systems in francophone Africa has been facilitated by the effective coordination of research, extension, and an integrated and effective marketing system.[60] This has, by and large, been provided by the Compagnie Francaise pour le Developpement des Fibres Textiles (CFDT), which has operated regionally in francophone West Africa. CFDT provided professionally sound research and extension, ensured adequate financing for the adoption of new technologies, and assured the availability of inputs, marketing, and processing facilities. This combination of appropriate technical recommendations and a well developed marketing system provided the basis for widespread adoption of technical recommendations.

The adoption of an improved "technological package" for cotton production in Mali transformed cotton production and the associated agricultural sector.[61] Between 1961 and 1989, Mali commercial cotton production increased more than eightfold. Yields rose dramatically, from 139 kilograms per hectare in 1961 to over 1,300 kilograms per hectare in 1988—the highest yield for rainfed cotton in the world. Cotton area increased from under 50,000 hectares to 247,000 hectares during the same period.

The types of technologies disseminated and adopted included fertilizer, insecticide, animal traction equipment, and equipment for applying agrochemicals. All elements of this package were widely adopted. Fertilizer is used on 98 percent of the area planted to cotton. By 1990, insecticide application was also virtually universal, with 96 percent of the cotton area receiving four insecticide applications during the growing season. Animal traction is practiced by 80 percent of the cotton growers.

Technological change in cotton has also transformed other parts of the agricultural sector. As commercial cotton culture and animal traction are introduced, farmers move from being marginally self-sufficient or deficient in grain production to being exporters. Cotton producers with animal traction grow 300 to 500 kilograms per person annually, and can market 30 to 50 percent of this production.[62] Animal traction reduced labor requirements for some operations such as tillage and weeding, but left overall labor use unchanged since more labor was allocated to harvesting and processing larger crop yields.

Cotton technology has also created employment and higher earnings for local blacksmiths who fabricate and repair animal traction equipment. A 1988 report indicated that 75 percent of the $10,825 average gross revenue of blacksmiths was directly attributable to making or repairing animal traction equipment or carts.[63]

Improved cotton cultivation and animal traction were also synergistic in other West African countries. The successful adoption of oxen cultivation in Burkina Faso (circa 1981) contributed to increased yield and cultivation of cotton.[64] Oxen power received massive support from producers. By the second year of introduction (1982), 72 percent of the farmers in the Volta Valley were equipped with oxen. In 1983, 80 percent of the producers were equipped with carts and teams, and nearly 80 percent of the land used to grow cotton had been tilled.

There appear to be several reasons for the spread of ox cultivation. First, farms had a labor constraint, and using animal draft release labor that could be used either to intensify cultivation or to expand cultivation (which allowed for a long period of use for the equipment). Most farmers adopted the technological package associated with cotton intensification, including early sowing (90 percent), fertilizer (92 percent but at lower than recommended levels), and weeding and spraying (72 percent).

Second, cotton provided the monetary resources required to purchase the equipment, both because of the cash proceeds realized from the sales and from the established credit system. Finally, fattening oxen before cultivation was a profitable activity that could be undertaken by farmers within their existing resources.

Cotton technology adoption has had environmental implications. The adoption of mechanical technologies made economically possible by cotton cultivation also permitted more extensive cultivation, including in many instances increased cultivation of grains. The combination of enhanced production, decreased fallow, and higher chemical input use appears to be associated with more serious environmental problems, including the loss of soil fertility associated with shortened (or eliminated) fallow periods. Such problems are now important constraints to increased agricultural productivity and the sustainability of the existing agricultural system.

The example of cotton in francophone Africa also illustrates some of the complex interactions between marketing systems and wider macroeconomic policies. Lower world market prices and increased budgetary problems in many francophone countries have made the relatively high cost of CFDT an issue. Higher costs, combined with the overvaluation of the currencies in the franc zone, have made cotton production in some countries less competitive internationally.[65]

Legumes and Tubers

Mechanized sowing for groundnut in Senegal's groundnut basin provides another example of widespread adoption. Over the past two decades, the groundnut cultivation system proceeded from one done entirely with manual labor to one in which virtually all the groundnut planted were sown by machine. Over 210,000 seed drills were sold over this period.[66]

Several factors were at work in the adoption of this technology. Sowing by machine (seed drills) is faster than sowing by hand and permits hoe weeding, which is also faster than hand weeding. This made it possible to plant more rapidly, an important objective given rainfall variability, as well as to sow considerably larger areas. Mechanized (hoe) weeding was also widely adopted, with nearly 300,000 hoes purchased. Mechanized harvesting of groundnut (use of the Firdou lifter) was also widely adopted. This speeded the harvesting process, making it possible to harvest the extra land that could be cultivated using the mechanical seeder.

The adoption of these technologies served both to increase productivity (for example, increases in yield and groundnut weight) and to permit increased groundnut cultivation. Adoption proceeded for reasons similar to those identified in the case of cotton. First, the technologies broke a key constraint (labor) and provided a way of carrying the benefits of a reduced labor constraint throughout the whole cultivation process. Second, there was a relatively established and secure market for groundnut, which gave farmers a basis for expected returns to cover the cost of their investment in the equipment.[67] Finally, the distribution of the equipment was easier than distribution of other inputs (for example, seed and fertilizer) that had to be made available on a timely basis each year.

The success of potato research in Rwanda provides an example of widespread diffusion of agricultural research with significant national impacts. The research, conducted by the Rwandan potato research program (PNAP) with support from the International Potato Center (CIP), has introduced six improved cultivars, with yields two to five times the national average under farm conditions.[68] CIP staff in East Africa estimated that commercial potato yields have increased by 30 percent in East and Central Africa through the application of improved technology and the use of fungicides.[69] Two of the PNAP cultivars (Sangema and Montsama), released in 1980, have been widely accepted by farmers. Sangema was the cultivar most prominent on 40 percent of the sampled fields, with Montsama predominant on another 25 percent of the fields.[70]

At least part of the success of the breeding program was its explicit recognition of the complexity of the farming system—characterized both by farmers' preference for a diversity of potato cultivars (to minimize risk and assure food security) and the widespread practice of mixed cropping. In many instances, this translates into a preference for early maturing varieties, even if they are more susceptible to late blight. Continued research on resistance to late blight and other diseases is ongoing, as well as research on techniques for the more efficient production of clean seed.

The success was also related to the presence of an internal market for potatoes. Rwandan farmers prefer to keep cultivars with high dry matter or starch content (generally lower yielding) for home consumption and "better taste." Cultivars with higher water content are produced for sale. Hence, significant improvements in yield, which might have been rejected if the only use were home consumption, were important as marketable commodities. By mid-1986, when good weather and much increased production generated a glut, the higher yielding varieties were more difficult to sell.

While the existence of an internal market facilitated adoption of improved varieties, the spread of follow-on varieties has been slowed by the limited capacity of the seed production facility, and the limited distribution system. A means of improving distribution considered by PNAP has been authorizing private traders to sell certified seed in rural markets, or selling directly to farmers.

Climbing bean varieties have also been widely adopted in Rwanda and in Kigezi, Uganda, both densely populated regions where this crop fits well into local mixed cropping schemes.[71] Successful food security research by Michigan State demonstrated that, contrary to local belief, there is a thriving domestic and (informal) regional market for beans. The Michigan State research also demonstrated that smaller farmers often purchase beans through these markets, relying on them for a key element of their household food security.[72] USAID has been a major source of funding for both the physical science research on beans and for the policy research demonstrating the existence and importance of the local and regional markets.

Research on cassava also appears to have had important impacts, although the data on cassava cultivation and yield are poor. It is estimated that cassava clones developed at IITA or based on IITA material are currently grown on about 1.5 million hectares in 12 African countries.[73] With development of the tissue culture technique, and strengthened linkages with national systems, it is projected that some 5 million hectares will be planted by the early 1990s.

In addition, there has been some success in a "two-pronged" attack on the mealybug and green spider mite (two principal cassava pests). Clones resistant to these pests have been identified and are being incorporated into high-yielding and disease-resistant clones. In addition, natural enemies of cassava from Latin America have been introduced and released in various countries. Effective control of these two pests could result in estimated net benefits of $220 million.[74]

Adoption Failures

There have been a significant number of instances in which research activities developed technically promising results, which were not translated into significant regional or national impacts. Hence, the experience with failures is rather rich. Rather than identifying specific examples of adoption and dissemination failures, this paper highlights the findings of several recent studies that have examined this issue in considerable depth.

In general, research activities fail to have a widespread impact for four basic reasons. The first, and most well documented in the farming systems literature, is that the research recommendations are at variance with either the mixed cropping system practiced or the farmer's own objective functions. The second is that the research results, while promising at the experimental level, do not address the actual constraints faced by farmers. This is one of the most common reasons for failure, and has been well documented in both micro studies and the general reviews discussed below. A third reason is that the it is uneconomic to adopt the research recommendations, even assuming that farmers had the resources to do so. This is particularly the case with recommendations for increased input use on food crops. The fourth reason is that the technology is made unattractive by systemic, rather than farm-level, considerations. The most generally identified systemic constraints are unavailable or unreliable supplies of critical inputs (including particularly fertilizer and improved seed), inadequate marketing, and unsupportive sectoral or macro policies.

In his review of World Bank research on food crops in sub-Saharan Africa, Carr found many examples of research that did not, in fact, address the principal constraints faced by farmers in particular agroecological zones.[75] Interestingly enough, many of these constraints are *not commodity specific* and are, hence, difficult to address systematically through commodity-based research. The principal farm-level constraint in the humid tropics of West and Central Africa is the inability to maintain soil fertility, given severe leaching under annual field crop production. The methods used to manage this constraint on compound farms (use of trees, organic waste and ash) do not apply to larger-scale field cultivation. This, he argues, limits the productivity of most of the major crops in the area, including cassava, yams, maize, and rice. In subhumid West Africa, the major farm level constraints are a shortage of labor at critical periods; tsetse fly infestation, which makes animal traction impossible; and soils that are by nature deficient in certain elements essential for plant growth. In the sorghum-millet belt of West Africa, the main farm-level constraints are limited, and unreliable, supplies of water. In the Savannah zone of East and Southern Africa, peak labor shortages and, in drier areas, erratic rainfall are the major farm-level constraints. In the East African Highlands, the major farm level constraint is land availability.[76]

There are a significant number of examples where research that provided good results at the experiment station level was unsuited to the mixed cropping environment in which farmers operated, including efforts in Nigeria to improve yam field practices, improve sorghum, increase plant density for millet, and use improved cowpeas that defoliate.[77]

Carr provides a large number of examples of research recommendations that were unattractive because they did not address basic farm-level constraints, including improved weeding/planting practices for lowland rice in Sierra Leone, Liberia, and Côte d'Ivoire, and weeding and staking recommendations for yams in Cote d'Ivôire.[78]

In a significant number of cases, research results have not been adopted because it is economically unattractive to do so. This is particularly the case with recommendations for application of fertilizer on food crops, *even when* the physical responsiveness of varieties to fertilizer are well documented. Carr provides a large number of instances in which this feature of a technological package limited its adoption and dissemination. They include the recommended use of fertilizer on cassava in Nigeria, the purchase of improved rice seed in Sierra Leone and Liberia, and the use of fertilizer on improved sorghum varieties in Nigeria.[79] A recent World Bank study on fertilizer and fertilizer policy concluded that the removal of fertilizer subsidies, coupled with the effects of exchange rate devaluation, could make fertilizer uneconomic for a wide range of food crop uses.[80]

Carr similarly finds instances in which the unavailability or erratic supply of inputs limited the adoption of otherwise attractive research technologies, including millet in Nigeria, where fertilizer availability was a problem; improved sorghum in Tanzania, where seed and seed dressing supplies were a problem; and maize in Tanzania, where seed supply was a problem.[81]

There are, in addition, many instances in which the failure of marketing systems to provide outlets has limited production growth in food crops, although at times this failure was also been associated with inappropriate pricing policies. Such examples include the handling of surplus sorghum and millet in several Sahelian countries, as well as in Tanzania, difficulties in providing timely producer payments in a wide range of African countries, and the insecurity of markets for domestic foodgrains as a constraint to expanding food grain production in Senegal.[82]

Recent evaluations of the French research experience in Senegal's groundnut basin illustrates the importance of economic and marketing considerations in fostering the spread of research results. Attempts to provide improved seed and seed treatments were hampered by the poor performance of the parastatals involved with seed and fungicide delivery.[83] Implementation of all other technological innovations involved the use of inputs (seed drills, hoes, inorganic fertilizer, lifters, plows, pairs of oxen) whose delivery depended on two key parastatals (ONCAD and SONAR). The evaluation concluded that "the operational cumbersomeness of ONCAD and SONAR generally formed an obstacle to the timely distribution of inputs requested, and particularly seed and fertilizer."[84]

Attempts to diversify production into cereals were stymied by the government's grain policy, reflected in the absence of a domestic market for potentially increased production. One researcher observed, "Why continue research on grain; why provide extension assistance to farmers for crops with no certain remunerative outlets?[85] The Michigan State team, studying the interaction between policy and technology adoption similarly concluded that thin and unreliable internal markets deterred farmers from planting more grain than was required for household food security needs.[86]

Regional Successes and Failures: SAFGRAD

The Semi-Arid Food Grain Research and Development (SAFGRAD) project provides an example of the evolution of U.S. involvement in regional networks, as well as an illustration of the shift in focus that has accompanied some of the learning summarized above.

The initial SAFGRAD concept represented a "grafting" of a more traditional crop breeding program (whose core was millet, sorghum, and maize breeding) with the newer emphasis on farming systems research. While some useful work was undertaken in each component of the project, there was not a strong integration of the social science/farming systems component and the more traditional breeding program.[87] Similarly, while the focus was on developing technologies for resource-poor farmers in rainfed areas, breeding programs were frequently limited by the poor fit between their products and farmer's preferences and requirements.[88]

Although the initial SAFGRAD activity was a regional one, it did not coordinate well with other institution and donor activities in the region. By the mid 1980s, this included a variety of maize-oriented research activities, including independent work by IITA/Ibadan, CIMMYT, as well as regional trail programs by the Sahel Institute (INSAH) and the Food and Agriculture Organization of the United Nations (FAO) and uncoordinated sorghum/millet research by ICRISAT.[89]

While the initial phase of SAFGRAD did conduct workshops and training, the final evaluation indicated that the lack of an explicit focus on "institutional development" limited the regional program's role in strengthening national research systems. The final evaluation concluded that SAFGRAD made a "significant, though relatively small" contribution to improving local research capacity.[90]

When the second phase of the SAFGRAD project was initiated, it was considerably restructured, with a heavier emphasis on supporting, and handing work over to, the national research centers.[91] The focus of SAFGRAD II is on strengthening four regional networks (West and Central African Maize Network, West and Central African Cowpea Network, West and Central African Sorghum Network, and East African Sorghum and Millet Network) and on improving the service capability of regional and national research institutions.[92] The resident agricultural activities at IARCs were phased out and replaced with substantial financial assistance to IITA and ICRISAT, as well as the establishment of the SAFGRAD Coordination Office (SCO). The SCO has recently assumed some responsibility for managing other networks as well.

SAFGRAD II appears to have made a more direct contribution to strengthening national and research capabilities than the initial SAFGRAD project. Its more comprehensive method for identifying major researchable constraints, and assigning responsibility for doing so to clearly identified research centers, appears to provide a better way of assuring that research is relevant to farmer's constraints. It also appears to have been a more effective method of focusing and directing informal training activities.

There have, however, been remaining areas of concern. While the "stronger" NARS are, in general, satisfied with the operation of the commodity networks, the "weaker" NARS feel frustrated with infrequent monitoring visits, inadequate funding for trials, low levels of technical assistance, limited information exchange, and minimal training opportunities.[93] In addition, there has been little integration of other research activities (such as CRSPs or centrally funded USAID projects) into the SAFGRAD networks.

Much attention has been paid recently to the need for more effectively coordinated regional/agroecological zone based research strategies and to the importance of formulating and implementing them as participatory programs. Some recent steps in this direction include: Southern Africa Development Coordinating Committee (SADC) / Southern Africa Centre for Cooperation in Agricultural Research and Training (SACCAR); Interstate Committee for the Fight against Drought in the Sahel (CILSS) / INSAH; Institut Recherche Agronomique Zaire (IRAZ); Intergovernmental Authority on Drought and Development (IGGAD); and Conférence des Recherches Agronomiques Africaines et Française (CORAF).[94] In general, the Special Program for African Agricultural Research (SPAAR) suggests that a consensus has rarely been reached and articulated on regional priorities. One major difficulty is that some of the areas with the highest economic priority may be the most politically sensitive, leading to a reluctance to conduct such activities in a regional setting. SADACC, however, has been successful in delegating responsibilities for various research components of maize to participating member countries.

In addition, there now appears to be a proliferation of networks and regional cooperation efforts, leading to a situation in which a relatively small number of scientists are distributed across a rather wide range of coordinating activities. Some streamlining of these activities is important to the wider effort to achieve greater cost effectiveness for African research institutions.

Patterns in Successes and Failures

While agricultural research has not brought a Green Revolution in Africa, there have been enough cases of broad research adoption to suggest some features associated with successful and failed adoptions.

1) In virtually all successful cases, there was both an improvement in physical technol-

ogy that increased production and productivity and a supportive market for the commodity.

2) Sucessful cases of research adoption in the absence of a cash market are relatively rare, and associated with severe threats to household food security (for example, cassava).
3) Research designed to increase production of subsistence crops has rarely been successful, especially when higher yields require purchased inputs or major modifications of established (mixed cropping) systems. Technologies were often uneconomical or at variance with the farmers' objective functions.
4) In the most successful cases, there were effective links between commodity markets, input supplies (for example, fertilizer, seed, agrochemicals, equipment), and credit. Partial success was possible where markets existed, but input supplies were imperfect. Poorly functioning markets and unreliable input systems led uniformly to failure.
5) There are several viable approaches for creating a supportive market system, including vertically integrated systems (involving either public or private sector organizations), informal markets, and liberalized, relatively competitive markets.
6) Many technologies were not successfully adopted because they did not address key constraints. Often these constraints were not commodity specific (for example, labor availability, rainfall variability).
7) Technologies that successfully loosened key constraints (such as animal traction in West Africa) sometimes created growth opportunities in multiple parts of the agricultural sector.

4. Conclusions

The previous review of strategies and adoption suggests two overarching conclusions.

Conclusion 1: Marketing Systems Are Crucial

The primary conclusion is that the operation of markets plays a critical role in the adaption of technology. This is true at the micro level, where the issue is economic feasibility for a particular farmer. It is also true at the sectoral level. The most successful cases of technological adoption occur when there are viable internal or external markets. More effective adoption occurs when there are effective links to inputs (via vertical integration or well functioning input markets) and marketing (again through vertical integration or efficient marketing systems). Market considerations should also shape research priorities. Research on commodities for which there is no viable internal or external market is unlikely to lead to widespread adoption or generate a substantial economic impact.

The challenge of an agricultural research strategy relevant to the 1990s is to develop a *workable* link between the dynamism and opportunities created by policy reform and privatization and the technological improvements that can flow only from agricultural research and that are essential to sustaining the growth that policy reform makes possible.

USAID, as well as other donors involved in policy-based lending, are at a crucial turning point. Policy reform, a necessary condition for making investment in both enterprises and technologies worthwhile, must now depend on such investments to deliver the increases in growth and welfare that African nations need so desperately. At this juncture, therefore, it is of critical importance that sound investments in improved productivity be made and that they be made in areas where they can provide the greatest possible support for the ongoing policy reform process.

Increasing agricultural productivity is critical to catalyzing growth in the 1990s. After a decade of experience with adjustment lending at both the macro and sectoral levels, the World Bank concluded that improved agricultural performance is essential to sustainable growth in sub-Saharan Africa.[95] Given the extensive commitment that the Bank has made to policy reform in sub-Saharan Africa, and its continuing commitment to foster growth stimulating reforms, it is important to understand why it has come to the conclusion it has on the importance of the agricultural sector and its enhanced productivity.

Despite some successes in diversifying economic activity outside the agricultural sector (for example, Mauritius and its enterprise zones), agriculture remains both the primary employer and a significant contributor to GDP in most African countries. The performance of the agricultural sector during the 1990s will, therefore, have a major impact on the economic performance of African economies and the welfare of a large share of the African population. If the agricultural sector operate as a “drag” instead of as an engine of growth, it will be increasingly more difficult to sustain the growth catalyzed by policy reform.

There is already substantial empirical evidence to support this argument. The Bank’s analyses of adjustment performance indicate clearly that the lack of supply response in the agricultural sector, in spite of some significant changes in sectoral and macro policies, has impeded growth.[96] The analyses conclude that the operation of many nonprice factors (including poor infrastructure, high transportation costs, and the lack of productivity increasing technologies) are largely responsible for the current state of affairs.

Conclusion 2: Research Systems Need to Be Results Oriented.

An important institutional conclusion is that institutions—even research institutions—need to be results oriented. Results need to be defined not only in terms of the number of research products produced (papers, trials, etc) but also in terms of the wider, practical utility of the products. It appears, however, that the best way to achieve this orientation is for research institutions to have direct, and real, links to the agricultural marketplace in their countries. This does not imply that there must be immediate payoffs to all agricultural research, but rather that there must be some significant portion of the research system that is *profoundly* geared toward responding quickly and effectively to market realities.

There are several ways to achieve this. One is to reorganize existing research institutes to increase their efficiency, management capabilities, and orientation toward practical results. Some of this is currently going on in the context of the policy dialogue, where 15 of the 21 countries undergoing significant policy reform—that is, Developing Fund for Africa (DFA) countries—are also restructuring their research systems. A second is to broaden the scope of research to include more private entities, who have a genuine monetary incentive to witness results from their work. Exploring such options should be an integral part of USAID's research strategy in Africa. A third is to generate and use economic information in defining research problems and priorities. A fourth is to create economic incentives for the production of relevant research—for example, by permitting individuals to capture some of the value of their research (such as U.S. arrangements where government researchers can hold patents on the products of their research).

These two conclusions, plus the lessons learned from previous strategies and the success and failures of adoption, support several recommendations for future research strategies.

1) **Identify and capitalize on research that will directly support *enhanced growth*.** Much has recently been written on the importance of establishing research priorities and on the utility of national or regional research plans as a means of achieving this. [97] Many of these plans, however, are established almost exclusively on the overall importance of the crops involved (for example, acreage planted, calories provided) and on the importance and tractability of scientific problems. Priority setting needs a stronger infusion of economic analysis, as well as an explicit attempt to link research to activities that hold significant development potential. Delgado provides some illustrations of how this process might work—for example, focusing on the objective of decreasing the unit cost of principal cereals that act as wage goods (perhaps through reductions in transportation costs, as well as through lowering production costs), examining the price conditions under which regional livestock feeding might become profitable, and examining the prospects production and commercial marketing of higher value products (such as meat and milk). This process of priority setting may, in turn, result in coordinated research across a number of disciplines, focused on the same identified objective.

2) **Focus on key aspects of the nonfarm components of agriculture that offer opportunities for significant reductions in cost and/or opportunities to break key constraints to growth.** There are a variety of

potential foci for research directed toward improving the function of agricultural markets, and these can be expected to vary across stages of marketing sophistication.[98] However, the previous review of successes and failures suggests one particularly important theme: the importance of finding ways to reduce the cost of fertilizer (and other modern inputs) in an market environment, perhaps through the development of more efficient marketing, transportation, and packaging techniques. The Michigan State University study of grain markets in Mali suggests the importance of providing effective information systems in order to create better operating, more competitive markets. Such research may well be applicable to other countries where grain markets are thin or in a state of transition from government controlled to privately operated.

3) **Make a major commitment to drawing into both national and international research systems private sector organizations, especially in areas where privatization is key to ongoing reform efforts.** Some of the most persistent input supply difficulties occur for modern inputs (for example, fertilizer, seed dressings, insecticides) where there are active privatization program underway in many African countries. Research involvement with such private groups, oriented toward exploiting new market opportunities offered by policy reform, could make a significant contribution to "impact oriented" research.

   In addition, as the ISNAR work demonstrates, a variety of private companies within African countries have the potential for involvement in research. Efforts should be made to encourage private enterprise to participate in research. The recent Michigan State study of private businesses in Southern Africa has identified a number of policy impediments to greater regional commercial activity.[99] Such impediments to regionally oriented research should be explored.

4) **Focus explicitly on noncommodity research that can address major African production problems,** including the preservation and enhancement of soil fertility, the development of sustainable systems for more intensive cultivation (for example, agroforestry), biological pest control systems, and the halting or reversing of environmental degradation.

5) **Broaden the commodity coverage of research to include research on the production and marketing of crops that have significant potential as export crops and/or commercial development within the country.** Criteria will be needed to focus resources and avoid simply overlaying new mandates on an overly diffuse research effort. Nevertheless, there is growing interest in the production and marketing of nontraditional exports, and some evidence (for example, Uganda) that programs of this sort can be both practical and successful.

6) **Make decisions on country and institutional priorities not only on the basis of their capability to produce research results, but also on the capacity to translate research into tangible impacts.** This recommendation goes beyond the case ISNAR and others made for improving the organization of NARS and national systems for delivering technical information to farmers.[100] It includes the presence of a policy and economic environment in which severe distortions do not inhibit the adoption of recommendations that would be economically sound in an undistorted environment or, conversely, encourage the development and dissemination of research results that make sense only in a tightly protected environment.

   In addition, it is important to foster, if not actively promote, linkages between researchers and policy makers, not only because such contacts generate better support for national research programs but also because policy makers are often unaware of the implications of their actions for productivity and income in the agricultural sector, as the Michigan State studies of bean policy in Rwanda and cereal substitution policies in Senegal demonstrate.

7) **Build the identification and assessment of impacts into both the organization and the conduct of research programs and research institutions.** In addition to being a practical requirement in DFA countries, effective impact identification and monitoring is key to the development of more efficient national research systems.[101]

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[3] Ibid., p. 11.

[4] Ibid., p. 10.

[5] Dana Dalrymple, "Development and Diffusion of New Agricultural Technology," USAID/PPC, 1977, p. 28, as cited in ibid., p. 22.

[6] DAI, *AID Experience in Agricultural Research*, page 23.

[7] A 1962 USAID manual order stated that foreign assistance could not be given to boost surplus food and feed production to substantially increase exports or to increase the production of surplus agricultural commodities other than food or feed. This, in effect, banned USAID-funded research on rice, sugar, wheat, vegetable oils, citrus fruits, cotton, and tobacco and impeded USAID's support to international centers such as CIMMYT and the International Rice Research Institute, which concentrated on wheat and rice, respectively. The policy was revised in 1968 to permit assistance to food crop production for domestic use, whether a surplus existed in world markets or not. The ban on research on nonfood surplus crops continued, however. DAI, *AID Experience in Agricultural Research,* p. 24.

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[9] Ibid., p. 14.

[10] Ibid., p. 13.

[11] Ibid, pp. 13-14.

[12] Ibid, pp. 13-14.

[13] Comptroller General of the United States, "U.S. Participation in International Agricultural Research," a report presented to Congress, January 27, 1978 cited in DAI, *AID Experience in Agricultural Research*, p. 31.

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[16] Devres, Inc., *Assessment of Agricultural Research Resources in the Sahel*, vol. 1: *Regional Analysis and Strategy* (Washington D.C.: Devres, October 1984), p.xlvii.

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[19] Ibid., p. 9.

[20] Ibid., p. 10.

[21] Ibid., pp. 11, 20.

[22] Ibid., p. 24.

[23] DAI, *AID Experience in Agricultural Research,* p. 11.

[24] Ibid., page 11.

[25] Ibid.; Anthony Pritchard, *Lending by the World Bank for Agricultural Research: A Review of the Years 1981 through 1987* (Washington D.C.: World Bank, 1990).

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[29] Pritchard, *Lending by the World Bank*, p. 21.

[30] Totals computed from ibid., pp. 29-35.

[31] Jack Anderson, Robert Herdt, and Grant Scobie, *Science and Food: The CGIAR and Its Partners* (Washington, D.C.: World Bank, 1988), p. 89.

[32] Ibid., p. 93.

[33] USAID, *Plan for Supporting Agricultural Research and Faculties*, p. 95.

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[35] The list is constructed from DAI, *AID Experi-*

ence in Agricultural Research, pp. 123-24.

[36] Ibid., pp. 125-26.

[37] Ibid., p. 127.

[38] See Elon Gilbert et al., *Maize Research Impact in Africa: An Obscured Revolution* (Washington, D.C.: USAID, June 1993), p. 27.

[39] For more discussion of this role, as well as the importance of policy, see Charles Johnson et al., *Kitale Maize: The Limits of Success*, Project Evaluation No.2 (Washington D.C.: USAID, December 1979).

[40] J. Gerhart, "The Diffusion of Hybrid Maize" (Mexico: CIMMYT, 1975), cited in Gilbert et.al., *Maize Research in Africa: An Obscured Revolution,* p. 27.

[41] The discussion follows Gilbert et.al., *Maize Research Impact in Africa: An Obscured Revolution*, pp. 27-32.

[42] Ibid., p. 35. The scenario used to evaluate the impacts compares the current situation with a scenario in which yields had remained static instead of increasing.

[43] The account follows Hans Jahnke, Dieter Kirschke and Johannes Lagermann, *The Impact of Agricultural Research in Tropical Africa: A Study of the Collaboration Between the International and National Research Systems* (Washington D.C.: World Bank, 1987), pp. 101-3.

[44] Gilbert et.al., *Maize Research Impact in Africa*, p. 63.

[45] Ibid., page 63-64.

[46] Michel Benoit-Cattin, "Recherche et Developpement Agricole: Les Unites Experimentales du Senegal," 1986 in Gilbert et al., *Maize Research Impact in Africa*, p. 28.

[47] Gilbert et al., *Maize Research Impact in Africa*, p. 67.

[48] Ibid., p. 69.

[49] Ibid., p. 71.

[50] The discussion follows ibid., pp. 55-56.

[51] Ibid., p. 55.

[52] Ibid., p. 61.

[53] Ibid., p. 63.

[54] Jahnke, *The Impact of Agricultural Research in Tropical Africa*, p. 102.

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